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FLYING

SOME PRACTICAL EXPERIENCES

BY

GUSTAV HAMEL

AND

CHARLES C. TURNER

WITH ILLUSTRATIONS

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PREFACE

MANY books have been written on the History and on the Theory of Mechanical Flight: Practical Flying has been comparatively neglected. The authors hope that by attempting to give some account of flying as practised to-day they may be assisting those who in the future, when aerial navigation is better established, may engage in the happy labour of writing about it.

They have tried to keep strictly to the practical side of aviation and they hope that the subject, which for them possesses strong fascination, will win for the book readers among those who can fly and those who have not yet flown.

The authors have received much help and encouragement from many people, and they must especially acknowledge the scientific interest which has enabled Mr. J. Elrick Adler to make a material contribution to the study of the physiological and medical aspects of aviation, the very valuable notes on wireless telegraphy contributed by the Hon. Guglielmo Marconi, and the contributions and information given by Mr. Henry Farman, Mr. Alec Ogilvie, Mr. Howard Wright, M. Pierre Maréchal, Mr. Holt Thomas, and by many naval and military officers.

The authors would also acknowledge the courtesy of M. Henri Roux, and the Editors of *Aeronautics*, *Flight*, and *The Aeroplane*, in according permission to use certain photographs.

GUSTAV HAMEL.
CHARLES C. TURNER.

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FLYING

CHAPTER I

APTITUDE FOR FLYING

In the early years of flying it was supposed that ability to become an aviator depended upon the possession of some quite uncommon degree of courage, or strength of nerve, or sense of balance. When the art of flying extended beyond pioneering, and flight schools were established offering tuition at moderate fees, it soon became apparent that many of the new flyers were quite ordinary men, and that flight was not beyond the capacity of women. In the opinion of the authors, however, flying is scarcely a suitable sport for women. So far no woman has become a really good pilot, although a few have attained a certain amount of skill. What may be almost termed the 'popularisation' of flying occurred about the year 1910. The aviation meetings of this period soon gave abundant evidence of the existence of many different degrees of flying ability, although at the early meetings the possession of the mere rudiments of the art was sufficient to bring rich reward in fees. At the schools it was quite impossible to say beforehand how a pupil would turn out. Some men of apparently perfect physique and unshakable nerve became very indifferent flyers, or even failed completely to learn, and this is astonishing considering there is nothing in the least difficult in the management of a flying machine. Yet a quite insignificant-looking pupil, pale and thoughtful, and having no inclination for violent exercise or for field sports, would take to flying as a duck takes to water. That there is in existence a special aptitude for flying cannot be doubted, and its distribution among the human race affords matter for interesting speculation.

Inasmuch as mechanical flying became possible only when the petrol motor was invented, it may be said that flying is a child of motoring, and flying so much depends upon the possession of a sound engine and upon its good management that it was hastily assumed by many people that the good motor-car driver was likely to become a clever aviator. This is by no means the case; many of the most skilful racing automobilists are simply terrified at the idea of driving an aerial motor vehicle. It will be generally agreed that motor road-racing is as difficult and dangerous as aeroplane racing, and probably it is to the realisation of the dangers of road-racing that some motorists owe their dread of flying, which, they think, must be far more hazardous because to ordinary steering is added control, or lack of control, in the vertical dimension. And yet it is for precisely this reason that ordinary flying—not racing—requires no more skill than road-racing, for there is more room, there are no 'tight corners' in the road sense, and there is practically no danger of collisions. In the air, too, less can be done in motor management for the reason that there are no gears to operate. On the other hand the steeplechaser who possesses what are known as 'good hands' has the delicacy of touch so important to the flyer.

The popular idea that the man without fear is the man to become a great flyer is entirely wrong. Most of the best flyers are men who are keenly apprehensive of possible danger, who never forget the presence of danger, and who have a very wholesome dread of the many causes of disaster. Nor are any of the best flyers men who no longer value life. The reckless, as well as the vainglorious, man may shine for a while in the aerial world, but his career will be very brief. In the aerodrome one meets many types, and more than one of them promises well, for there are different varieties of flying, all of them excellent. The extremely excitable man, who is never in repose, will probably learn to fly easily, but he has not the qualities to become a master. His opposite, the very dull, listless, heavy individual, will probably during his lessons never show the slightest perturbation, and will essay his first solo flight with perfect apparent *sang froid*. He is, however, quite likely to smash his machine at this trial.

Although flying is easy enough, it does require for its safe exposition men of more than average steadiness, both of nerve and of character. It requires the type of man who is indifferent to public opinion, who has the courage to appear to be overcautious, and who has the will to refrain from flying even when greatly desiring to fly. But in the very nature of things aviation has attracted the exactly opposite type of man, the man with a certain amount of reckless spirit, but with little steadiness of nerve, whose great interest is to avoid the imputation of cautiousness, and to appear before the public as possessing great daring. That said, it may be remarked that it is the simplest thing in the world to fly an aeroplane after a fashion—to fly well is quite another matter—and the chief difficulty is that of resisting every temptation to become momentarily careless. It must not, however, be supposed that there is no margin for bad piloting or for mistakes; within limits, a man may make a wrong movement with the lever, he may tilt the machine up to a dangerous position, and can yet be able to return to normal flight without an accident. Flying is not such a terribly critical business that it need unduly tax the nerves; in ordinary weather the pilot has a fairly comfortable time of it, in cross-country work merely having to keep his attention fixed upon suitable landing places for emergencies. On the other hand, accidents being serious, aeroplane driving will, for some time to come, require care and steadiness that might seem excessive in other forms of mechanical locomotion.

Well-balanced character is of supreme importance. An American aviator who gave sensational exploits during a long period was so impressed by the number of accidents that he resolved never to use an aeroplane again. A few months later the exploits of M. Adolphe Pégoud filled him with envy and he resumed flying. He declared he would outdo M. Pégoud. At his second or third flight in the attempt to beat his rival he exceeded all bounds, plunged into a group of people, killing two of them. That type of man, needless to say, only does harm to flying.

One authority has sought to show that the ability to fly is a question of ethnology. He says,[1] in effect, that all the best flyers, and, generally speaking, all the quick-witted men who succeed in the modern struggle for existence, are descendants of adventurers of sorts,

[1] *The Aeroplane*, August 28, 1913.

but essentially of fighting men. By the process of elimination in battle those who were not quick-witted were killed off and left no descendants. The survivors bred men of their own kind. It is from such stock that good flyers are made. For this reason, claims this authority, 'it has been found difficult to train non-commissioned officers and men of the Royal Flying Corps to become good aeroplane pilots, who, almost without exception, come from the commission ranks.' This appears to open up a contentious subject, but there does appear to be some ground for the belief that racial temperament may have a good deal to do with ability to fly well. The French, characteristically, led the way. Relatively, the Germans at first were indifferent flyers, neither so dashing nor so enterprising, and labouring at times under what seemed to be almost an excess of caution—although, Heaven forbid that anything should appear in this book deprecating even excess of caution in flying.

Naturally, a man should be thoroughly sound physically. He must possess not only a strong constitution and general physical fitness, but his eyesight and hearing should be normal, as any deficiency in these senses would mean an almost insurmountable handicap. Needless to say, his respiratory organs should be sound, and he should be able to withstand sudden, and frequently extreme, changes of temperature. The size and weight of the man are less important although, clearly, an aviator who weighs fourteen stones is, other things being equal, at a disadvantage compared with a man weighing only nine stones: his machine has seventy pounds less fuel-carrying capacity. There should, of course, be no heart weakness. But given alert mental faculties, the right sort of eye for judging distances, and sufficient coolness and judgment, any young man who possesses these requirements ought, with perseverance, to turn out a good aviator. But saying this does not exhaust the subject, for there is good reason to suppose that in the medical examination,[1] which should be imposed upon every candidate for flight tuition, certain questions of heredity would be taken into account with the purpose of rejecting the descendants of epileptics or confirmed drunkards. This is mentioned on the authority of Dr. Falchi, a professor in the Italian National School of Military Aviation. With regard to eyesight, although the wearing of spectacles is a slight handicap, it is no insuperable obstacle to good flying, provided that the sight so aided is about normal; but the extremely bad-sighted person who, even with spectacles, can only see imperfectly ought not to fly—he will not be able to judge quickly enough his distance from the ground when attempting to land.

The best age to learn to fly is from eighteen to thirty. Most of the clever trick flyers have learned between the ages of twenty and twenty-eight—for example, Messrs. Morane, Garros, and Chevillard. Slightly older men, between thirty and thirty-seven, are capable of much endurance in long-distance cross-country flying. It is very rare that a man over forty is at all suited for flying, and although quite a number have learned between the ages of forty and fifty-five they have not, as a rule, become good pilots. The late Mr. S. F. Cody, who started flying at forty-seven, was a remarkable exception, but then the age-limits referred to above only concern average men. Exceptions will be found to every rule. Mr. Cody was a most unusual type, he was flying extremely well at the age of fifty-two, and shortly before his death he said he knew no reason why he should not

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[1] See note at end of book.

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be flying at eighty. It is certain that the man who has learned to fly in early manhood, and who takes care of himself, will steadily improve with experience, and there is nothing in flying which calls for its abandonment by such a man until he is well on in years. It is probably unwise to learn to fly in very early youth, and although many certificates have been issued to boys of eighteen, aviation undeniably calls for the exercise of a certain amount of caution, a quality more often absent from youth than from men of upwards of twenty years. Dr. Falchi, judging the matter purely from the physician's point of view, says the age at which officers should become pilots is between twenty-five and thirty-five. He says that after the age of thirty-five the circulation of the blood and the respiration in the average man have become somewhat weakened, rendering him less able to adapt himself to entirely new conditions.

Because two or three aviators have abandoned flying, alleging as a reason exhaustion of their nerves, it has been roundly asserted that an aviator's career is limited to three or four years. This statement may, without hesitation, be denied. By taking reasonable care there is no reason why a man should not continue to fly for many years; his nerves will not get tired, nor will a mishap or two shake his courage. As in every other pursuit that calls for the exercise of any quality of mind or body, the health must be preserved, and sufficient and regular sleep and proper nourishment are perhaps more important than anything else. A man should have, every day, eight hours of good sleep. If an aviator be in good condition and enjoy proper sleep and food he will not go wrong in any contingency. Improper care due to excess either of food or drink lead to internal disorder while flying, and fatal accidents have been caused thereby. It is most important to avoid flying when hungry. One learns these things by experience. In a flight from Brighton to Hendon a pilot started without breakfast early in the morning, and had got within sight of Brooklands. When flying at the height of 3000 feet he was seized with hunger faintness, and only just managed to get to earth safely before his strength left him, after which he lay beside his machine for some minutes absolutely exhausted.[1]

Air-sickness is much more likely to afflict the aviator if he be out of condition, and especially when he is hungry or suffering from lack of sleep. Air-sickness is not a respiratory trouble brought on by the deficient supply of oxygen at high altitudes, but is akin to sea-sickness, and is due to the rolling and pitching of the machine in rough air. Some flyers are more subject to it than others, and they are, generally speaking, men who are bad sailors; but with experience and practice even the sensitive flyer becomes less subject to the malady. It is not a bad plan to try to overcome this weakness by keeping a food lozenge in the mouth.

While on the subject of keeping in condition it is well to emphasize the necessity for temperance in all things. Alcohol need not be prohibited, but the flyer should be strictly moderate in its use. Any motorist who has been unwise enough to dine over well will agree that on the following day he is likely to suffer from some loss of skill, shown possibly in 'scraping' some other vehicle on the road. While it can be said that flying under ordinary circumstances calls for no exceptional qualities, a terrible penalty may be paid for temporary mental sluggishness; and, while this is so, the wisdom of keeping in as perfect condition as possible should not require to be emphasised. The aviator should have suitable recreation, and this recreation should be of a nature to keep his mind and his body in activity.

---

[1] Flight by G. H., March 1911.

The question of temperament will be considered presently, as well as many matters psychological, but here it is well to set down as emphatically as possible the rule that a man should never fly if he feels in the slightest degree out of condition or unwell. It is certain that an aviator's disinclination to fly must have its base upon some temporary defect of body or mind, and, without being unduly sensitive or timid, he should realise this and overcome the cause rather than tempt Providence by running the danger of overtaxing his powers. It is possible to become temporarily 'stale' by flying too much without periodical rests. Flight instructors, and aviators who attempt endurance records, run the risk of overtaxing themselves; and when flying it is important to avoid becoming exhausted. No matter how much desired the given goal may be, and how much tempted the aviator to continue until it is attained, he should descend at the first sign of exhaustion. Personal rivalry between aviators, as in other affairs, leads to each man doing his utmost, but it is possible to carry it too far, and no man who is not capable of owning himself beaten, but would rather risk his life in a vain effort to outshine a rival, is fit to have charge of a flying machine. Healthy rivalry, however, will merely lead to good work. Of flying, far more even than of golf or anything else, it may be said that the Golden Rule is 'Do not press the game.' There are on record instances of aviators continuing in flight after their limbs had become numbed with cold. The risk of such a course is tremendous. It is highly probable that a contributory cause of the fatal accident to Chavez at the termination of his flight across the Alps was the numbing of his hands and feet from cold.

It need hardly be said that experience counts for a very great deal in flying. Much of this experience is of an undefinable character. Most aviators would find it extremely difficult to explain 'how they do it,' and so much do aviators differ from each other in power that those of the highest attainments appear to possess instincts and senses denied to the average. The most careful analysis, however, fails to discover any quality that cannot be cultivated by every one. As already stated, in the early days it was supposed that an aviator required to possess almost a gymnast's sense of equilibrium. This is not the case, although it is highly probable that, assuming he possessed the other necessary qualities, a professional equilibrist would make a better flyer than a man who cannot stand on a six foot wall without overbalancing. It is highly probable that the sense of balance can be cultivated, but the average man possesses it in a sufficient degree for ordinary flying. The normal man possesses in the inner ear certain organs known to anatomists as the semi-circular canals, and it is from these organs that the sense of equilibrium comes. There are three semi-circular canals—one vertical, two horizontal—and they are filled with a liquid containing a pigment, the pigment for some unknown reason being indispensable to their efficiency. So far as the writers are aware, it has not been before remarked that in flying this sense of balance chiefly concerns lateral balance. Most aviators enveloped in fog and unable to see any objects by which to judge their position know instinctively when the machine is tilted up either to the right or to the left, but cannot tell small deviations, fore or aft, from the horizontal. They are apt to get into a dangerous position, tilted up or down forwards, before they realise what has happened. Laymen would probably go astray in attempting to explain the reason. The reader will find interesting light on kindred questions in the note by Dr. Adler at the end of the book. Here, however, it may be remarked that in ordinary walking the limbs, in progressing step by step, preserve a proper balance, accommodating themselves by adjustment, of which the walker is quite unconscious, to the slightest upsetting influence. In flying the absence of a keen sense of fore and aft balance when there is no visible horizon is, fortunately, compensated by the mechanical arrangement of the machine and by certain instruments that can be carried. For one thing, the revolution indicator, by showing a rapid acceleration, will warn the pilot that the machine is on a down slope, or if the revolutions rapidly decrease, apart from any other contributory cause, it is due to the machine climbing. This descending and this climbing attitude may become exaggerated and dangerous long before the airman feels anything unusual. He may carry an instrument known as the inclinometer, usually based upon the spirit-level principle and showing him quickly enough when the machine becomes tilted. Better still, he can carry an incidence indicator, which will show him the angle of the machine relatively to the direction of the flow of air. Having no instrument for this specific purpose, an aviator has in his petrol-gauge or, failing that, in his swinging compass a rough and ready inclinometer.

All aviators are not alike in their sense of balance. There are experienced pilots who do not agree that lateral is much easier to preserve than fore-and-aft balance. As will be explained later, most machines are less delicate as to lateral than to fore-and-aft control, a circumstance that must affect the pilot's impressions to some extent. At any rate, some aviators flying in clouds have, without noticing it, got the machine steeply tilted up to right or left.

Of many conditions that perplex the airman, fog is one of the worst; over all country it is perilous. In a flight near Amesbury on Salisbury Plain, while practising for his certificate, an aviator early one morning flew suddenly into fog. In a second all sense of direction and locality was lost, and although the machine was comparatively slow, flying at not more than forty miles per hour, it will readily be understood that such a situation was embarrassing in the extreme. Attempting to come down he found himself heading straight for telegraph wires which, however, he managed to clear easily. He then turned, heading, as he supposed, for open ground near the sheds, but after a few moments he came suddenly and unexpectedly close to the ground. But this was a small cliff, a disastrous place at which to alight. At all costs it was necessary to continue flying, even though it was impossible to tell which direction to take. In a few moments he found himself charging more telegraph wires, and turning sharply to the left through the fog, yet another row of posts and wires suddenly became visible in the cloud. It was now hopeless to attempt to get out of the muddle, there was not room to clear the wires, and the only thing for it was a landing. To avoid striking the dangerous obstacles a very sharp downward turn had to be made, the machine alighting unevenly and sustaining some trivial damage.[1] What is distressing to the airman in fog is the impossibility of knowing whether he be slightly climbing or slightly descending, with the result, and especially on a very fast machine, that he may find himself charging full tilt into a hill, or trees, or houses, without time to save the situation. When flying suddenly into or out of cloud or fog, a momentary dizziness is felt due to a sudden straining of the senses to adapt themselves to new conditions.

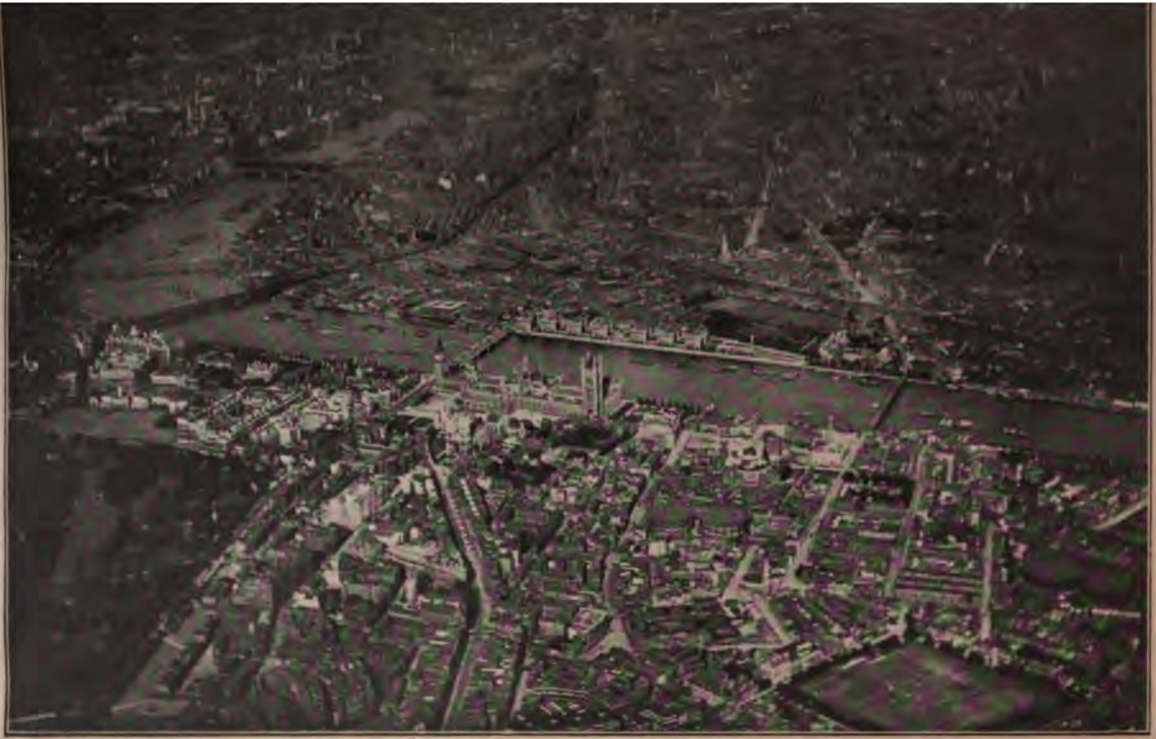
---

[1] Flight by C. C. T., April 1911.

After a few weeks of flying the aviator begins to find himself more and more at home in his new element, very much as a swimmer becomes accustomed to the water, or a motorist becomes able to perform most of the labour of driving without conscious effort. In his first flights the airman must observe extreme caution, and he has to bear in mind what it is incumbent upon him to do in view of the eventualities of which his instructor has warned him. With growing experience, however, he will encounter many of these incidents and will easily overcome them. This not only gives him confidence but implants the lessons on his mind in a way that makes them almost part of his nature. The burden of flying becomes smaller and smaller ; indeed, the danger is that he may become over-confident and careless. Some men never seem to pass out of the novitiate stage, and every flight is to them a painful effort. Flying more than anything requires of all the faculties constant readiness : when for some reason that cannot be foreseen, the motor stops and the airman is compelled to make a descent, he must at that instant be ready to choose a landing-place within the range of the machine, and to arrive at it without misjudgment or vacillation of mind. The penalty of failure is almost certain to be costly, and may involve personal injury. Compared with this the difficulties of bad weather when a gust or eddy of air may strive to upset the machine are easily overcome.

When the aeronaut's temperament is more thoroughly understood consideration will be given by physicians to other details than those concerned with physiological fitness. A great number of questions relating to psychology are suggested, and some day, no doubt, these will be analysed and answered. In so many ways flying is unlike anything else. It has yet to be seen whether the taking to a new element—an element that until the present century was regarded as unattainable for practical navigation by human beings—may not have some profound effect upon the nature of man. It appears to call for the greatest possible development of the senses. To one man flying is delightful; to another it is quite a discomfort, accompanied by painful sensations as of being suffocated. The great majority of people, however, find it enjoyable enough. A blind man was taken up as a passenger, and afterwards he said, 'It was delightful and made one feel nearer Paradise. I could quite easily distinguish when the machine was rising and falling although it was travelling at about forty-five miles an hour. The rush of air was by no means disagreeable.' It would be interesting to know whether a blind man's consciousness of direction, speed, and balance is more acute than that of seeing humanity. In a railway train a passenger, by shutting his eyes, can become quite uncertain as to whether he is travelling forward or back. In an aeroplane, of course, the rush of air upon the face more or less indicates the direction, but even the practised pilot is unable to tell from the strength of this rush of air whether he be travelling at fifty or sixty miles per hour.

The apparatus for mechanical flight has steadily improved since the days when M. Ader, the Wright Brothers, and M. Santos Dumont, made their first flights. While its fundamental principles have not changed, its reliability, strength, and general efficiency have very greatly increased, and development continues along several different lines of design. But progress in flying is even more due to



THE PANORAMA OF LONDON

(Taken by Mr. W. J. S. Lockyer, on May 22, 1909, from the balloon 'Corona,' at a height of 2,600 feet)

the increased skill of aviators. Those who remember the early days of cycling will recall the marked inferiority of the average cyclist as compared with his representative to-day. Every boy with a bicycle nowadays can do on his machine what only the most skilful riders, and even the trick riders, did in 1890. Progress in flying has been far more rapid and striking. When he was giving his first exhibitions of flying in Europe, at Le Mans, Wilbur Wright would never make an ascent unless the air was so calm that the smoke of his cigarette went straight up, and even then he would not ascend except on very dull days, or in the morning and towards dusk. Until the end of 1910 it was quite exceptional for a pilot to fly in a wind of twenty miles per hour. By the summer of 1913 the flyer of average skill, and many military pilots, would willingly go out in a wind of thirty miles per hour, and there were quite a number of aviators who would fly in a gale. At that time men had flown in wind of fifty-five and sixty miles per hour. It is very common for aviators to fly for long distances across country in high wind. A following wind, of course, facilitates long distance work.

The clearest proof that the art of flying has advanced more rapidly than the machine is that any good pilot of to-day, given a machine of an old pattern, either a biplane or a monoplane, will fly almost, if not quite, as well as with a thoroughly modern craft. This, however, would be putting such a machine to a strain for which it would probably not be suited, for many older aeroplanes were structurally inefficient.

The art of flying has advanced in steps, most of them marked by some sensational incident, and, it must be admitted, some of them due to that very personal rivalry which, in so many cases, has a sinister element fraught with danger. Hubert Latham's historic demonstration of flying in a high wind in October 1909, at Blackpool had an immediate influence upon the art of flying. Until that time aviators were fine-weather birds, none had attempted to fly in a wind of twenty miles per hour. Bad weather was experienced at the Blackpool meeting, and the aviators were exasperated by the inaction enforced by wind and rain. On the evening of October 21 Latham promised a friend that he would at all costs make a flight on the following day. The morning broke stormily, but while all the other airmen kept their machines under cover, and the wind was blowing in strong gusts, Latham took out his Antoinette monoplane and prepared to ascend. His friends attempted to dissuade him, but he would not be moved from his purpose. To the astonishment of the spectators he got off the ground without mishap and began his great struggle with the elements. Down wind his speed was over ninety miles per hour, beating up against it, however, he was held almost motionless. At times the aeroplane pitched and rolled in the most alarming way, and for moments disaster seemed imminent. He flew for ten minutes and landed without mishap after what, at that period, was a wonderful performance. From that time the power of the wind to prohibit flying began to diminish. This was the year, too, in which M. Louis Blériot dashed across the Channel with so uncertain and feeble an engine that he seemed literally to fly in the face of Providence.

In the following year Chavez, a Peruvian aviator, flew across the Alps, and, although he sacrificed his life, the moral effect of that tremendous victory was incalculable, for it showed that the mightiest strongholds of the air are conquerable. But better illustrating the point now being made was the general adoption in

1910 of facilitating turning movements by 'banking.' Hitherto, turning movements had been executed with difficulty, taking up much space. In some biplanes a turn could scarcely be effected in less than three-quarters of a mile. On account of the greater speed of the outside plane in turning, an aeroplane naturally has a tendency to lift on that side. At the aviation meeting at Nice, in 1910, pilots of Wright biplanes turned a pylon near the Grand Stand far more adroitly than any of their rivals, because by warping the wings they could cant the machine up quite steeply and spin round without slipping away to the side to any noticeable extent. All machines at that period had rudders for steering, but few had any effective means for the control of lateral balance. Observing the success of the Wright pilots, Efimoff, a Russian, piloting a Farman biplane, produced the same effect by means of the balancing flaps at the extremities of his planes, and before the end of the meeting all the flyers, save those of Voisin machines, which had neither balancing flaps nor warping arrangement, but had fixed vertical panels, were banking steeply at the turns. This involved a new mastery of the machine and essentially safer flying.

To show how that very ordinary descent the 'dive' was first regarded it is only necessary to quote from a newspaper of May 1910:

'A supreme attraction has been discovered for this summer's flying meetings—the "vol plané," or aerial dive. Mounting to a great height, an airman cuts off the ignition of his engine, thus robbing himself of all motive power, points his elevating plane earthwards, and comes diving down at a speed approaching 100 [1] miles an hour.

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[1] On machines of that time the vol plané was seldom at a speed of more than seventy miles per hour.

'To the spectators it appears as though he were dropping sheer to destruction, but just before he reaches the ground he rights his machine dexterously, and manages to alight safely. Such judgment and nerve does the feat require that only one or two of the most famous airmen have as yet attempted it—notably M. Paulhan, Efimoff, and Captain Bertram Dickson, the Englishman who defeated all foreign rivals at the recent Tours meeting.

' "So fascinating is the trick to spectators," explained Captain Dickson yesterday, "that I am now being offered large sums of money to perform it in addition to competing in the ordinary way at the flying meetings. At Tours, people came again and again in the hope of seeing a vol plané. The sensation in doing the trick is extraordinary. The whole art of it is to keep control of your machine by descending swiftly. After you have cut off your engine, were you to go straight on through the air the aeroplane would gradually slow down until it began to drop backwards. This would mean certain death, of course.

' "What you have to do is to summon up sufficient nerve to throw your lever forward and turn your machine as though you were falling to the ground. You find yourself, as the aeroplane dips over, looking straight down at the aerodrome below you. Then the earth seems to rise up as though it were going to hit you. You feel as if you were descending in the fastest lift ever built.

' "The critical moment comes when you have to alter the angle of your elevator, check your speed, and at the same time preserve sufficient momentum to glide safely to the ground. The feat is the most sensational yet devised for any exhibition of flight." '

It was in the same year that the first real vol plané on a monoplane was accomplished, a memorable instance being afforded by M. Alfred Leblanc. One day when that famous pilot was flying a Blériot monoplane driven by one of the earliest fifty horse-power Gnome motors, his engine stopped at the height of about 3,000 feet. The onlookers were aghast at the prospect of a bad smash, for although biplanes had managed to come down safely under such circumstances, it was not supposed that the relatively small-winged monoplane could make a safe glide. But M. Leblanc promptly dipped the head of the machine and glided to earth at quite a good angle. From the ordinary vol plané to the spiral vol plané was but a short step, and with it came the knowledge that an aviator had a bigger choice of landing places and could descend in quite a small space in the event of having to make a sudden descent.

Trick-flying, which will be referred to more particularly in another chapter, came into vogue principally in America, and led to several fatalities. It was performed chiefly to please a sensation-loving crowd, yet it cannot be denied that it had, and has, its uses. The real corkscrew descent, derided as sensational at one time, teaches an aviator that his machine will do almost anything he demands of it, and that in no accidental circumstances need he despair. M. Pégoud, the first deliberate exponent of upside-down flying, said: 'Accidents are sometimes brought about by the pilot being seized with panic. The aviator ought to be able to master his nerves under all circumstances, the capacity to do so is one of the qualities necessary to become a good pilot.' Trick-flying has done a great deal in teaching this lesson. Moreover, many of the feats that were regarded as mere tricks have now become part of the daily art of flying, so it may be said that no aviator ought to venture on a cross-country voyage unless he is confident that, in given circumstances, he can come down in a spiral or a corkscrew, and that should he be completely turned over by a squall of wind he can right the machine again.

On the subject of women and flying, Mrs. Maurice Hewlett, who was the first Englishwoman to be granted an aviator's certificate, says :[1]

'Women will never be as successful in aviation as men. The reason I feel that women can never compete with men as aviators is because they have not the right kind of nerve, the nerve that unites full knowledge of every danger, and judgment in handling difficulties, with cool daring. Now that is the kind of nerve women do not possess. They have physical courage, to be sure, and some of them have made interesting flights, but very few of them have any practical knowledge of flying.

'Miss Quimby,[2] for instance, had plenty of reckless courage, but she really knew very little of aviation, and never fully realised her danger. Of course, when she was face to face with a necessity for judgment and presence of mind she failed, and I think it has been so, and will be so, with the majority of women pilots.

'You know, women have never been as successful at driving motor-cars as men, nor are they able to sail great vessels. They simply lack that indefinable kind of nerve men possess.

'There are two women pilots of whom aviators speak in praise, Mlle. Dutrieu and Madame de Laroche, but neither of these women could begin to compete with Mr. Hamel or M. Védrines. They could not enter on long flights where physical endurance is required as much as any other faculty. Why, M. Védrines told me that during one big race he slept in his clothes for a week, snatching his nap as best he could under the wings of his machine. Can you imagine any woman doing that?

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[1] *Daily Sketch*, May 2, 1913.

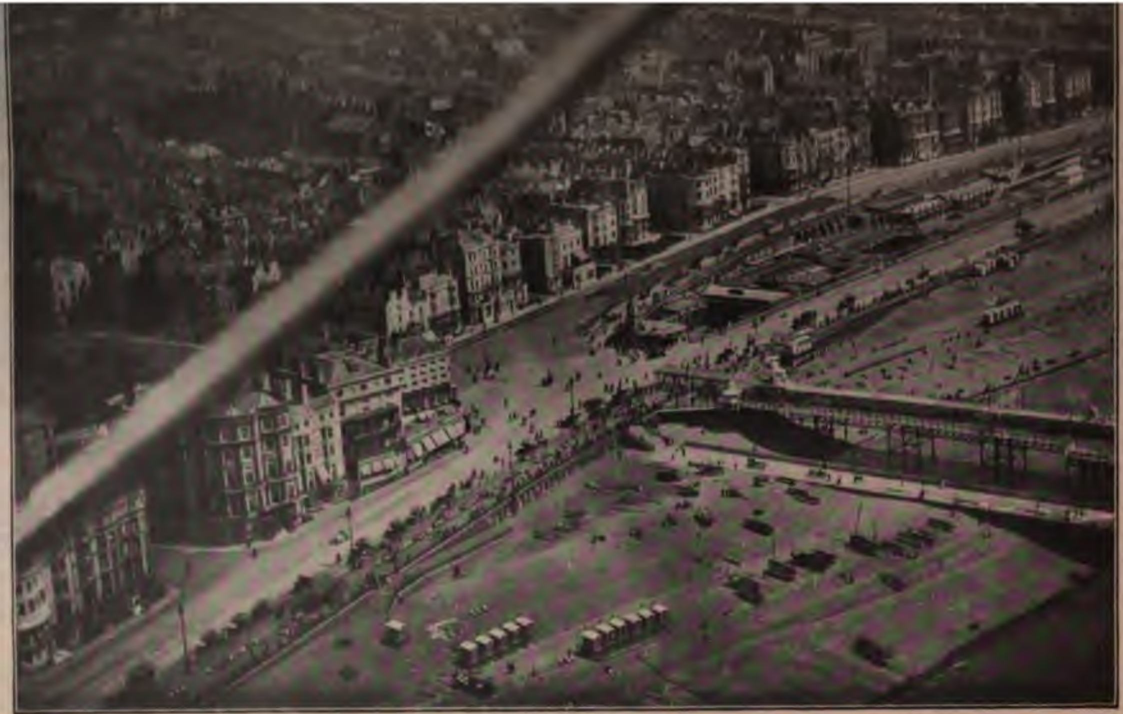
[2] Miss Quimby was killed on July 1, 1912.

'Of course, I am sure that one day in the future the mysteries of air currents and the manifold things that bewilder us now will all be solved, and then women will drive their own monoplanes as now they often drive their own motor-cars—in fact, they may probably go in more for aeroplaning, because when it is thoroughly understood, no doubt it will be easier than driving a motor, but just now it is very difficult and dangerous.'

CHAPTER II

THE AVIATOR'S FIRST LESSONS

MANY people who want to learn to fly, find out first which is the easiest of all the machines and decide to take tuition upon that, with the idea that they will be able to learn other types afterwards with greater ease. This is probably a wise plan, but it does not follow that, because a man can fly a slow biplane of the engine-behind type, he can pass easily on to a tractor biplane or a monoplane. Indeed, there is some reason to believe that the habit of flying upon an engine-behind biplane rather deters a man from ever becoming a good monoplane pilot. On the other hand, there is little doubt that any good monoplane pilot can readily master a slow biplane. There is little difference between piloting a tractor biplane and a tractor monoplane. The former is, however, somewhat easier to land, as the pilot has a better view of the ground. Probably the reason so many certificates are taken out for piloting biplanes is the fear with which people approach flying at all. It is the common belief that it is an extremely risky business, and that a man's passage through a flying school is fraught with danger which he ought, if possible, to limit by taking his lessons on the safest possible machine. If, however, it were possible to find out how many accidents have occurred during tuition, and to analyse them, it would not be found that learning



BRIGHTON FROM AN AEROPLANE

(Taken by Mr. E. L. Dower from Mr. E. Pashley's Biplane)

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to fly a monoplane is any more dangerous than learning to fly a biplane. Nowadays a flying school is a well-organised establishment where the pupil of quite ordinary capacity cannot easily come to grief; the real trouble begins later, when he has won his certificate and is beginning cross-country work.

It may be well here to describe briefly the flight course both on the monoplane and on the biplane. One of the first things that a pupil should lay to heart is the need to proceed slowly. It appears to be imagined in some quarters that a pupil's merit is shown by the rapidity with which he qualifies for his certificate. There have been occasions, no doubt, when exceptionally gifted men have made light work of the first stages and have proved themselves born flyers in a very little while; and some of these have been fortunate enough to get through the subsequent stages in their career without serious mishap, but it must be taken as a general rule that the man who learns to fly with a fortnight's tuition, or less, is not so sound a flyer as a man who takes two months, and this for the simple reason that he cannot in a fortnight have had many flights either as a passenger or by himself, nor can he have had time to watch other people flying, to observe their methods and to profit from their mistakes. Lieutenant Conneau ('Beaumont') wisely says: 'An aviator's wings take long to grow. Unfortunately, most pupils are in great haste to get on, and in the schools dash, high spirits, and audacity, meet with the master's approbation. The poor, reserved, reflective fellow may be considered as out of place.' He quotes an instance taken from one of the French Aviation Camps—'Most of the young men who practised there were remarkable for their enthusiasm, and were mad in their attempts to fly. They were over-zealous in mounting the "taxi." They laid wagers as to who would be first to "hop." One day a new pupil arrived. He was quiet, with a rather sullen look, and displayed no haste in clambering into the "taxi"; but he paid great attention to all that went on. For the first few days his dress, his high wadded boots, his overalls, large gloves, ugly goggles, and woollen cap, were the only signs which stamped him as an aviator. The teacher thought he was afraid; he tried to encourage him by pointing out to him the others as examples. But our silent fellow said nothing; he quietly climbed into the machine and went on in his quiet, thoughtful way. And then, all at once, he took everyone by surprise, for he successfully passed his examination, long before his fellow students, and became a first-rate pilot.'[1]

In the first chapter the question of the temperament most suitable for flying was considered. Many people are appalled at the prospect of leaving mother earth for an excursion into the air. There is no ground for this fear, and the sensations experienced in going up are not in the least terrifying. However, the fear is very widespread and it must be taken into account. A man who has done any ballooning has, of course, got over this part of the trouble, small as it is.

If it be possible, a pupil, in order to learn to fly, should go to a school where he can live in the neighbourhood and be separated as completely as possible from the distractions of business or other pursuits. For a few days concentration of his attention is very much to be desired. His first solo flights are all the easier and safer if he has become so completely imbued with the idea and theory of flying that he controls the machine with instinctive skill. It is not necessary that he should have a very extensive knowledge of the science of flight, nor need he have ever driven a motor-car, the latter accomplishment being only of use in so far as it accustoms one to speed and to the petrol motor, and it is only when the machine is on the ground that a knowledge of the details of the motor is serviceable: it is not possible in flight to give close attention to them, and one can only control the motor by the use of the petrol sector regulating the supply of fuel, the switch, and occasionally the throttle, which anyone can master in a few minutes. As to knowing the science of flight, it is perfectly true that the best pupils are those who are more or less acquainted with it, and particularly those who are familiar with the work of the pioneers, and know how their difficulties were overcome. Invariably, knowledge of this kind indicates that the pupil is an enthusiast, and has been one for months before taking up aviation. Certainly, the very ignorant pupil, who has not the remotest idea why an aeroplane flies, starts with an initial disadvantage. One would say that his point of view is wrong.

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[1] *My Three Big Flights.*

It is usual in biplane tuition to begin by going up as a passenger with the instructor and watching him manipulate the controls. This lesson is repeated, and the pupil is allowed to place his right hand on the lever, with that of the instructor, in order to feel its movement. There can hardly be too many flights of this kind, and machines that are equipped with duplicate controls enabling the pupil not only to feel the movements of the lever, but also those of the rudder-bar with his feet, are helpful. It will be well for the pupil if, after the first flight or two, some vicissitudes of ordinary flying are encountered in the form of eddies and gusts of wind, to say nothing of enforced landings. He is a fortunate pupil who becomes sufficiently impressed by the fact that flying demands constant alertness while he is in the pupil stage, and before he begins to fly alone. Watching other aviators fly, and discussing every little detail with them, is very useful. Bad weather which prevents outdoor work may be a real blessing. The pupil cannot spend too much time in the sheds, becoming familiar with the machine, and even sitting in the pilot's seat and working the controls. There are a great many things to learn besides piloting which it were well to learn while preparing for his certificate.

Most aeroplanes have similar control movements, whether they are monoplanes or biplanes, and whether the wings be warped or have, in place of flexible tips, projecting hinged flaps. The ordinary control consists of a pivoted foot-bar for the rudder; by pushing the right foot forward the rudder is turned to the right for wheeling to the right; to turn to the left the pilot pushes his left foot forward. All other movements are controlled by a pillar surmounted either by a handle held in the pilot's right hand, or by a wheel which he can hold by either hand or both hands, as he pleases. This pillar moves in any direction, to and fro, or from side to side, and in combinations of these movements. Its movements to and fro actuate the elevator, and in a manner that makes its control instinctive. Thus, if the pilot desires to raise the head of the machine for climbing he pulls the lever towards him; if he desires to depress the head of the machine for descending he pushes the lever forward. To raise the left wing of the machine he pulls the lever slightly to the right, the sensation being that of lifting the left of the machine up. To raise the right wing he pulls the lever away from the right. Many of the movements are combinations of fore-and-aft and lateral, and become small circular movements. After each movement of the lever, or wheel, the control is brought back to the normal position. For example, having once got into the angle desired for descending, the pilot brings the elevator back to the normal position. If it were left depressed the angle of descent would steadily increase and soon become extremely dangerous. The pilot in all these operations 'feels' the machine answering to his touch.

Before his first solo flight the instructor will have given the pupil a number of rules, and the pupil should learn these rules not only by heart, but so thoroughly that they will be put into force almost unconsciously when occasions arise. These rules may be summarised as follows in the form they were received in the course of tuition now being described:[1]

'When the machine has attained almost sufficient speed for lifting, gently depress the elevator by pushing the lever slightly forward. This assists the tail off the ground. Then, almost instantly, pull the lever slightly towards you. This lifts the head of the machine and depresses the tail. The aeroplane then rises from the ground. Push the lever forward to normal, and then, in order to gain altitude, again pull it back very slightly, and only for an instant. Continue these movements, ascending by small, almost imperceptible steps.

'While flying, do not watch any particular part of the machine or landscape. Your first inclination will be to keep your eyes glued on the elevator. Keep your eyes on all. Do not look at the foot-lever. Make all the lever movements gently. Correct all deviations from even flight as they occur—do not wait until they become pronounced. But you will find that the machine itself has a large measure of stability, and will almost find its own balance without your help. Never allow the head of the machine to become tilted upwards—this is a dangerous position if it lasts. All movements of the lever from the normal should only be momentary; having made a desired movement, instantly bring the lever back to its usual position.

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[1] That of C. C. T. on a Bristol biplane, in 1911.

'At the slightest irregularity in the noise of the motor depress the elevator to descend. [These rules are for pupils, of course.] And having come to the descending angle, return the lever to normal until you are near the ground, when you elevate to bring the machine to the horizontal for landing. Apart from engine trouble, in making your first descent, however, come down gradually, reversing the manner in which you ascended. Skim along near the ground, and cut the engine off to alight. If the engine should stop while in full flight, you must descend vol plané. At the instant the motor stops push the lever forward hard until the machine is at about thirty degrees, and the elevator is about level with your feet. Do not be afraid of making the downward path steep. There is a wide range in the angle at which you may descend with perfect safety, but the beginner is liable to err in making the gliding path too gradual. The machine will find its own gliding path when you have brought the elevator down and returned the lever to its normal position. On nearing the ground do not be in a hurry to pull the elevator up. Wait until it appears as if the skids are almost touching the ground; then gently pull the lever back, "feeling" the machine into a horizontal position for alighting.

'All the movements will come perfectly natural to you, and the machine itself will help you.

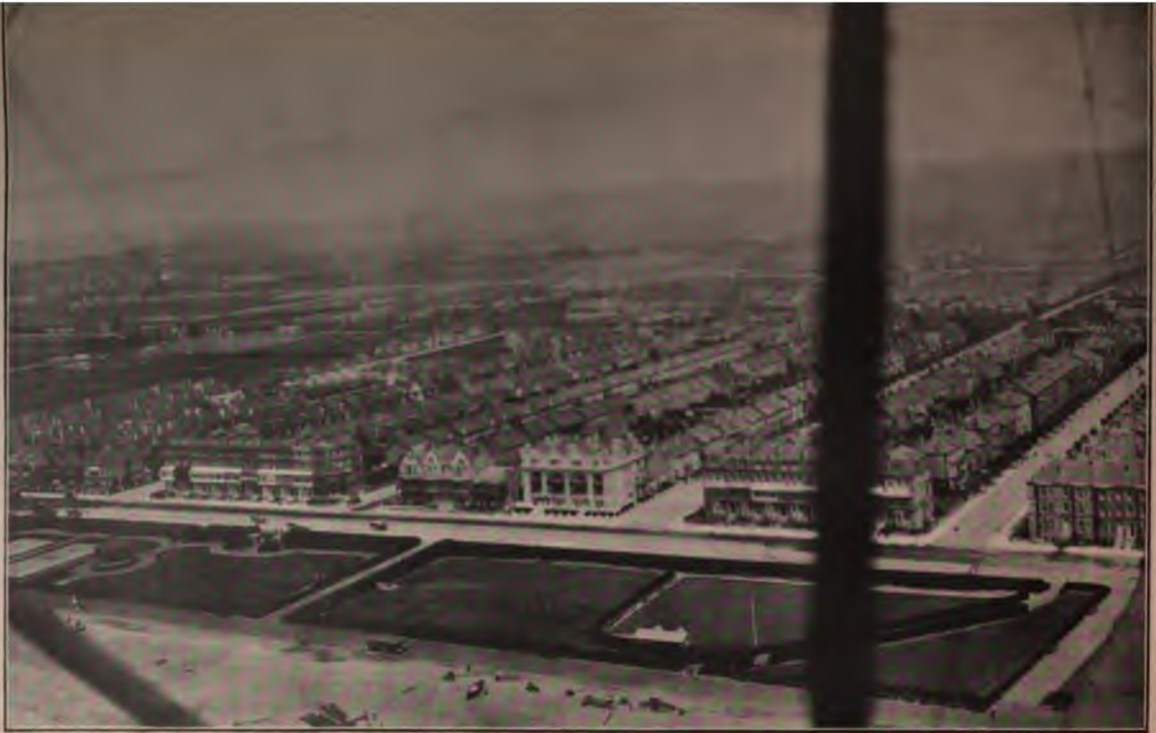
'In flight, when you find the machine tilted up on your right, press the lever away from you towards that side of the machine very slightly. You will find that this presses the right wing down, and you bring the lever back to normal as the machine gets level. If the nose of the machine dips, pull it up by drawing the lever towards you. If it rises, push it down, by moving the lever forwards. If the left side tilts up, pull the lever over to the left. Never exaggerate your movements. In calm weather you will find that for quite long periods the machine requires absolutely no attention. Of course, you must always be watchful.

'Before making a turn to right or left, increase your altitude, because in all turning movements it is advisable to depress the elevator a little and the machine falls slightly. For turning to the left, push the left foot forward. This deflects the rudder. For turning to the right, push the right foot forward. In turning it is better slightly to "bank" the machine up on the outside of the turn. Thus, for turning to the left, while pushing the left foot forward, you bring the hand-lever over a little to the left, returning it to the normal, but then, if necessary, repeating the movement. If you have "banked" the machine up excessively, stop the turning movement at once with the foot-lever and correct the banking by means of the hand-lever, and bring the head of the machine down.

'And now for a few general rules for pupils. Never attempt to rise during a turn. Never trouble to elevate to recover from "remous" or from "holes in the air." If a side gust tilts the machine up excessively, turn into the wind by steering into it, and at the same time correct the cant with the hand-lever—*i.e.* if the left wing is forced upwards turn to the left by pushing the left foot forward, and at the same time pull the lever over to the left. In turning in a wind be careful about "banking." If the wind is blowing from the outside of the turn "bank" very cautiously, but if the wind is blowing from the inside of the turn you can safely "bank" a good deal. Never attempt to land in a side wind of much strength: you can easily see by observing the movement of the ground. If the machine has any sideways motion, turn into the wind until the ground is moving straight towards you; then land. Never land with the engine fully working. Switch off before touching the ground. But you can run along the ground under power by switching the engine on and off alternately [this refers to flight with a Gnome motor]. To come to a stop, run on the ground a few yards, and then slightly elevate to bring the tail down, which acts as a brake.'

These are general rules which a pupil who has had a few passenger flights has no difficulty at all in acting upon instinctively, although they appear, perhaps, somewhat formidable in print. More or less they apply to all aeroplanes, although, as we have seen, the methods of control in different machines vary. They apply to machines with the Gnome motor, which has not, like some of the fixed-cylinder motors, a great speed range. In a Gnome motor, speed can be slightly altered by regulating the petrol supply; but fixed motors have a wider range of power. On the other hand, having cut the ignition of the Gnome motor off by means of the switch, the pilot can, after some seconds' interval, switch on again. It is, by the way, advisable when switching off to cut off petrol, otherwise the cylinders get choked and fail to fire when desired. Or it is a simple matter by switching on and off to use up the charges in the cylinders, thus preventing choking.

In his first flight the pupil should not ascend higher than a few feet. His impressions will probably be very confused, and it will seem to him afterwards that he has not learned anything at all, and that he only



HOVE

Taken by Mr. Clarence Winchester from Mr. E. Pashley's Biplane

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escaped a bad smash by accident. This, however, is an illusion. He has put into practice the effect of his teaching, without reasoning the matter out, and on the second or the third flight he will begin to feel himself quite at home in the air.

Most of the rules given above apply also to monoplane tuition, but in the case of the monoplane it is more necessary to be able to run the machine about on the ground with something like certainty of direction; indeed, a pupil who can control his monoplane on the ground has got half-way towards flying. The biplanes of the slower kinds are far more tractable in this respect. It is not at all easy for a beginner to master the art of 'rolling' a monoplane in straight lines with the tail well off the ground. The machine has a tendency to go in any direction than the desired one, and the curious thing is that movements of the rudder do not have immediate effect, but the machine obeys them only after a few seconds taken, apparently, for consideration. At first, what usually happens is that the pupil finds the aeroplane making all sorts of turns that he has not in the least sought to make. It will be readily understood that the machine is easier to control as to direction when it is travelling at a good speed than when it is going slowly, for the rudder-plane only has due effect when it bears upon the air with considerable force. Most monoplane pupils break wood during rolling practice, for the machine, until it is thoroughly mastered, has a way of spinning round in a small circle and a tendency to slip sideways. Once the art of rolling is mastered and the pupil can go from one end of the ground to the other and back in a straight line, he is ready to make his first 'hop,' but he must not, on any account, attempt a turn in the air, nor must he fly higher than a few feet. And he must be strictly enjoined to alight with plenty of room to spare to come to a stop before hitting a fence or any other obstacle. He will gradually be allowed to fly higher in straight lines until he feels quite confident that he can make a half-turn. Probably he will have been using a 'school' machine driven by an engine only just powerful enough to lift it off the ground, and not powerful enough safely to turn in the air. Reckless pupils have, nevertheless, in defiance of the instructor, attempted to turn at the second, or third, or even the first flight, with an under-powered machine; a bad smash has invariably followed, and in some cases, the foolhardy one has been hurt.

One thing every pupil must bear in mind is that he must never switch off the engine when he is in a 'tight corner,' or in difficulties of any kind, for that means loss of speed and controllability. The average flight pupil has a strong inclination to switch off whenever anything untoward happens. Yet should a smash be absolutely unavoidable it is of the utmost importance that the engine should be stopped before impact, otherwise the wreck will be all the greater and more dangerous because of the revolutions of engine and propeller; and, worse still, in the event of the petrol tank bursting and the pilot being pinned down, it is extremely likely that the flood of petrol will be ignited by the magneto and the pilot burned before he can be rescued.

If the pupil has not wasted his opportunities he has, by the time he is able to take his certificate, learned a good many things besides piloting his machine. If he desire to become a sound flyer there are many things he ought to know; and these things concern chiefly little practical points of adjustment, attention, and repair rather than a perfect knowledge of motor mechanics or flight mathematics.

A good cavalryman need not necessarily be a veterinary surgeon, but the really good trooper, who is equal to all ordinary emergencies if left to his own devices for a week at a time, is a man who has learned by experience how to take care of his horse. This is not a book on motoring, and since the aeroplane motor is, to all intents and purposes, practically the same machine as the automobile motor, it would be needless repetition to go into all the information concerning its care, which every chauffeur is supposed to have at his finger-tips. The average aeroplane pilot need know no more about his motor than the average motor-car owner who can drive. He will, however, be none the worse for having a practical acquaintance with the ways of this important part of the machine, which is only another way of saying that a man cannot know too much. But there are many good pilots who lack expert knowledge of the motor. One largely used type of aeroplane engine is, however, so different from the ordinary automobile motor that a few words regarding its peculiarities will not be out of place. The Gnome motor, with cylinders rotating on a fixed crank shaft, is here indicated.

The inlet valves are a source of trouble. When one of these fails, warning is given by an explosion and a jet of flame. Every pilot ought to know how to take out an inlet valve and put a new one in its place. The removal is effected by means of a grip, a tool consisting of a tube, one extremity of which is ringed with teeth. This is inserted in the top of the cylinder that needs attention. The teeth fit into notches in the piston, holding it steady. Then a second and smaller tube is inserted into the first, and the teeth at the end of this second tube fit into notches in the inlet valve which is then readily unscrewed and taken out. It may be taken to pieces; but it is always advisable to carry a spare inlet valve when on a cross-country flight. The trouble is probably due to a broken spring or rocker, and of these parts spares can readily be carried on the machine. It is usually difficult to ascertain which cylinder contains the defaulting valve, and it is the experience of most people that in seeking for it, no matter at which end of the series of cylinders the search begins, the trouble is not located until the last or the next to the last is reached.

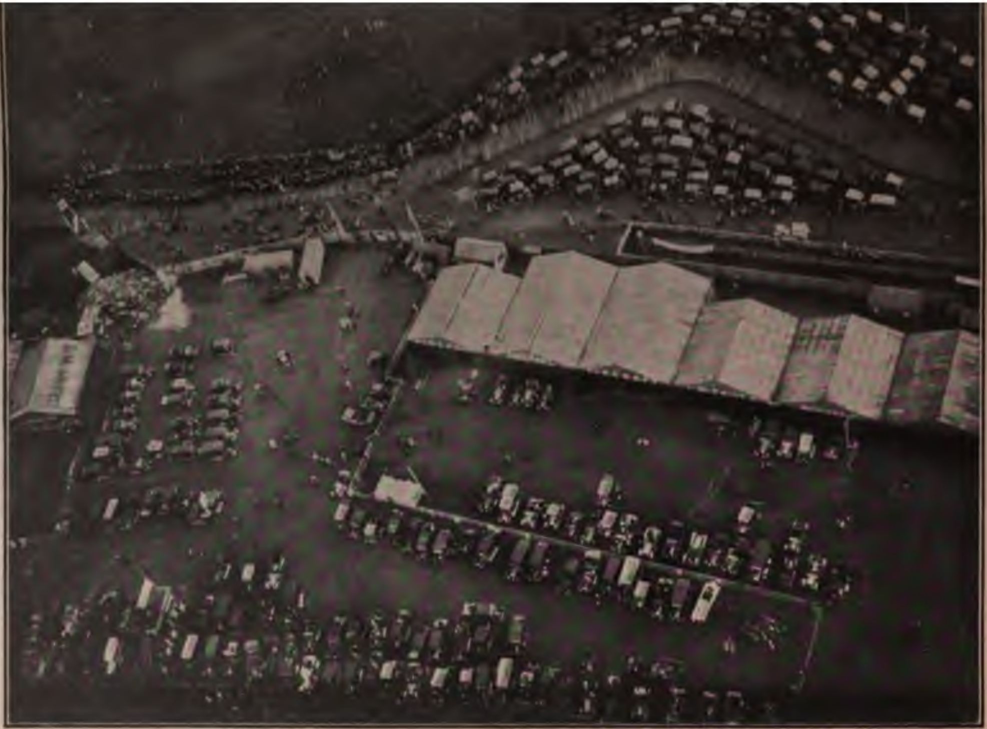
A common source of slight trouble is due to the plugs becoming covered with soot, but a plug can so easily be taken out and replaced by a new one that it would be superfluous to describe the operation here. Spare plugs should be carried, and the old plugs can easily be cleaned with petrol. The cylinder which is not getting its mixture fired is easily found by passing the hand over all the cylinders and finding the cool one. It is a very useful precaution to give the distributor a clean at each descent. Many enforced landings are due simply to the distributor carbon becoming oily and dirty, thereby causing a short circuit. The distributor is easily cleaned by passing a rag over it, and the carbon should be taken out and cleaned at frequent intervals.

A pilot ought to know how to put a new wire into any part of the machine, and also how to adjust the control wires, but all these operations can be mastered after half-an-hour's tuition. They are referred to here because there is in existence a class of pilots who have not troubled to learn even these elementary repairs. Some pupils are extraordinarily indifferent to all that concerns the mechanical details of their machine. Their attention from the first is naturally concentrated upon learning to fly, and unless a man has a liking for mechanics he will fail to learn a number of simple but very useful details that would afterwards stand him in good stead. It is, perhaps, a pity that, in the tests which a pupil has to pass in order to obtain his certificate, nothing more than actual flying is included. A pilot ought to be able to take a wing down and put it back again, and he ought to be able to replace the propeller. Yet probably there are quite a number of aviators capable of putting a propeller on the wrong way. In most of the agreements, under which pupils learn to fly, it is stated that instruction in the mechanics of the machine will be given. But it is to be feared that in the majority of schools this clause is not carried into effect thoroughly. Every one of the points mentioned ought to form part of the pilot's apprenticeship.

There is more to break in a small way in a biplane than in a monoplane. In the majority of cases any breakage in the latter type requires expert mechanical assistance to repair, but in a biplane many of the small breakages that occur in rough landings can be easily repaired by the pilot with help from the nearest village. One of the important things for the biplane pilot to learn is the difference between the two sets of wires that help to brace the parts of the structure together. Of these sets of wires one set are known as flight wires. They are those which extend from the bottom centre of the machine outwards to left and right to the top. Upon them depends to a very large extent the holding of the structure together in flight. The wires that extend from the top centre of the machine downwards to left and right serve to preserve it against the strain caused in rolling along the ground. They are, then, of secondary importance. All pilots should very frequently examine the wires in the chassis to see that they are of equal tautness; and biplane pilots should be particularly careful to observe that none of the stanchions, or struts, are loose in their sockets.

A pupil should be warned against the danger of making an ascent after a landing without coming to a stop on the ground and seeing that everything is in order. In the case of a bumpy landing something in the fuselage or the landing carriage may have broken or got loose, in the former case endangering the wings, and in any event making it possible that a subsequent landing might entail serious damage and even danger.

Before being permitted to take a machine across country a pupil ought to have had experience as a passenger on cross-country flights, and the good instructor would give his pupil, on expeditions of this kind, actual experience in emergency landings. He would, without warning, switch the engine off in order to illustrate the need for swift decision as to a landing place. At anything less than 1,000 or 1,500 feet there is no time for much consideration. At great altitudes, of course, a machine takes so long to glide down that a more or less deliberate choice may be made. Before getting to the cross-country stage of his tuition a pupil ought, by second nature, to dip the head of his machine the moment the engine stops. At present flight tuition covers only the period until the pupil has obtained his certificate. The conditions for obtaining the certificate have been made more difficult from time to time, but they still lack cross-country work, and the stipulation as to altitude flying is altogether below the proper standard. A pilot ought not to venture across country until he has made a vol plané from a height of 3,000 feet and until he can come down from that height in a spiral. In beginning cross-country work, the first essential is deliberateness. For the inexperienced man to venture on a long trip over difficult country is demanding too much of skill and of fortune.



AVIATION MEETING AT HENDON

The Enclosures seen from an Aeroplane

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Soon after he begins to leave the friendly shelter of the aerodrome the beginner will be confronted with the difficulty of getting off bad ground. In this case it is well to avoid too prolonged a run before rising, and care should be taken not to bump on to the ground again once having left it. This, however, is often done by too quickly straightening the machine out from the climbing position. What happens is that the angle of the wings is reduced too quickly and the acceleration of speed is momentarily insufficient to keep it up at the finer wing angle.

In windy weather it is important for the novice to avoid turning until the machine is at a good altitude. In all kinds of weather this is a sound rule, although a machine that is climbing well, having more than adequate power, will come through difficulties that find out the weakness of underpowered craft. Near the ground the wind blows irregularly, and eddies are often encountered.

After a trip across country the beginner is apt to forget the direction of the wind. He should cultivate the practice of observing the signs. Smoke or flags, of course, point the way, but sometimes none of these are in sight. In the absence of such aids, it is well to pick out some fixed point in the landscape close to the landing place for which he is bound, and then head the machine straight for it, observing the direction in which the machine drifts away from the straight course. When the machine keeps straight on the mark he may safely land in the same direction if it be a head wind, or, by turning round and facing it, if it be a following wind. The latter will be easily indicated by his relative speed over the ground, the difference—even with a slight wind—being very noticeable.

In landing, of course, the pilot must use judgment, and, whatever machine he is flying, he should, whenever possible, avoid coming down in sheltered places such as clearings in woods, or on the lee side of a hill or high building.

The beginner should not attempt cross-country work except in favourable circumstances. He should never venture out in foggy weather, which is so serious a danger that even the first-class aviator avoids it. Cross-country work in low-lying clouds is very risky, and, without actual fog, the conditions are sometimes prohibitive. In a flight over Newcastle a pilot found himself enveloped in clouds at a height of no more than 150 feet, and this in the immediate vicinity of the Tyne and its bridges.[1]

As he makes progress the flyer will be prone to venturesomeness and taking risks. Immunity from accident will incline him to the belief either that he is specially favoured by fortune or that he is a remarkably gifted person. It would be difficult to say which is the more deadly and foolish delusion. The beginner should be particularly cautious in making steep descents. It is true that the pupil is more apt to err in the direction of making his glides too flat, but after the pupil stage is passed he may run to the opposite extreme. It must be remembered that the high velocity of very steep descents makes the control more effective, the speed attained, moreover, necessitating quickness of thought and hand. The beginner should proceed very cautiously, gradually accustoming himself to rapid descents. The effect of gusts on a machine descending steeply may be very marked, and very dangerous unless the pilot has acquired experience by slow degrees. A strong head gust may make the machine suddenly take a steeper path, whereas in ordinary horizontal flying a gust causes the head of the machine to tilt up. Descending steeply on a following wind the aviator will almost certainly find that a sudden great diminution in the velocity of the wind near the ground will cause the machine to take a nearly vertical path.

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[1] Flight by G. H.

It is most advisable for a pilot to be fastened in his machine, otherwise when tilted at a big angle he may be thrown out of his seat. There is no excuse for carelessly getting into a dangerous situation. From the earliest the pilot should accustom himself to the use of the revolution counter, and he may also carry an air-speed indicator showing the relative speed of the machine to the air and indicating clearly if a dive be too steep. Air-speed indicators are, however, somewhat fallible instruments. An incidence indicator is desirable, although if the revolution indicator be carefully observed it is of subsidiary importance. Many aviators use lengths of string tied to the struts to show whether the machine is tilting excessively, or, in turning movements, insufficiently. The reader will find further suggestions as to needful precautions in the chapter on Accidents and their Prevention.

The authors have read with profit the answers to a 'Questions for Pilots' Competition in an aeronautical newspaper,[1] and they take the liberty of quoting here a few of them :

An aeroplane of the Farman type requires the right foot to be pressed against the rudder bar in order to fly in a straight line. Explain what incorrect adjustments may cause this fault, and how you would proceed to correct it.

Since the aeroplane has a tendency to fly to the left, the centre of head resistance must be to the left of the centre of thrust. This may be caused by the following:

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[1] The *Aeroplane*, November 9 and December 14, 1911.

- (*a*) Distortion of the main planes causing:
    - (1) Too great an angle on the left (causing increased resistance on left).
    - (2) Too small an angle on the right (causing decreased resistance on right).
- (*b*) Similar distortion of the elevator or tail planes.
- (*c*) Incorrect adjustment of aileron control wires.
- (*d*) Combination of any or all of above causes.

Examine machine to find which of above faults exist:

- (*a*) Probable cause, incorrect tightening up of tension wires. Adjust wire strainers to correct.
- (*b*) See answer to (*a*).
- (*c*) One of the left-hand aileron control wires too short. As the flaps hang down whilst the machine is at rest this is not easily noticeable. Have all the four flaps held out simultaneously and note faults, if any; correct by adjusting wires.

Also the motor may be out of line, so that the propeller does not rotate in a plane at right angles to the direction of motion of the machine. Also if the tail plane is so adjusted as to be too high on the left side (from the back) and too low on the right. This creates a turning movement which has to be corrected by the rudders as described.

An aeroplane of the Farman type requires the control lever to be pulled over slightly to the left (thereby depressing the right ailerons) in order to prevent it tilting while flying. Give the possible causes of this fault.

Causes and adjustments may be similar to those already mentioned. However, as there is no tendency to slue round, the deformation must be such that the centre of head resistance and centre of thrust coincide.

The main weights may be incorrectly placed, thereby shifting the centre of gravity to the right of the centre of pressure. This is not a very likely cause, and would be due rather to a fault in design or construction than incorrect adjustment.

The motor torque may be unbalanced, but as the machine has a tendency to rotate in a clockwise direction only a motor rotating in the opposite sense (*i.e.* counter-clockwise) could cause the trouble.

Generally in a case of this sort it is found that the two ends of the plane are untrue; one may have too much angle or the other too little. Very often it is due to the extension (if one is fitted) being incorrectly adjusted in this manner. The remedy is, of course, obvious: alter the length of the wires until the plane is true.

In an aeroplane of the Farman type: What is the effect on the flying of the machine of (1) *too small an angle of incidence of the tail planes,* (2) *too large an angle of incidence of the tail planes?*

1. If the tail angle is too small:
   The tail will tend to droop, and the machine is liable to dive backwards, especially when turning corners or if the motor slows up. The elevator will have to be depressed to correct the trouble.
2. If the tail angle is too large:
   The tail will have a tendency to rise and the machine is liable to dive forwards. To

keep the tail down the elevator must be raised.

It is noticeable that whereas the small angle of the tail might improve the stability, the decrease of angle on the elevator would neutralise the effect. Similarly in (2) the unstable attitude of the tail would be corrected by the increase of angle on the elevator.

What circumstances would, in your opinion, justify the trying of a propeller of larger pitch on any machine you may be flying?

1. If your present propeller is not absorbing the engine power, and there is no room for one of larger diameter, one with a bigger pitch might be used.
2. If the machine requires a higher flying speed than that for which the propeller you are using is designed, a larger pitch and smaller diameter or geared-down propeller must be used.
3. This is really a particular case of 2. At high altitudes or in weather when the density of the air is very low, the flight speed is higher, and a larger pitched propeller should be used. The change in mass of the air at different levels is pretty considerable, *i.e.* about 0·08 lb. per cubic foot at sea level and 0·05 at 30,000 feet. Although the latter height has not been reached on heavier-than-air machines, nevertheless the difference of weight at 10,000 feet would make considerable difference. Of course, at the same time, whilst more air by volume must be dealt with, *i.e.* a higher speed required, the resistance is materially decreased also.[1]

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[1] See chapter on High Flying.

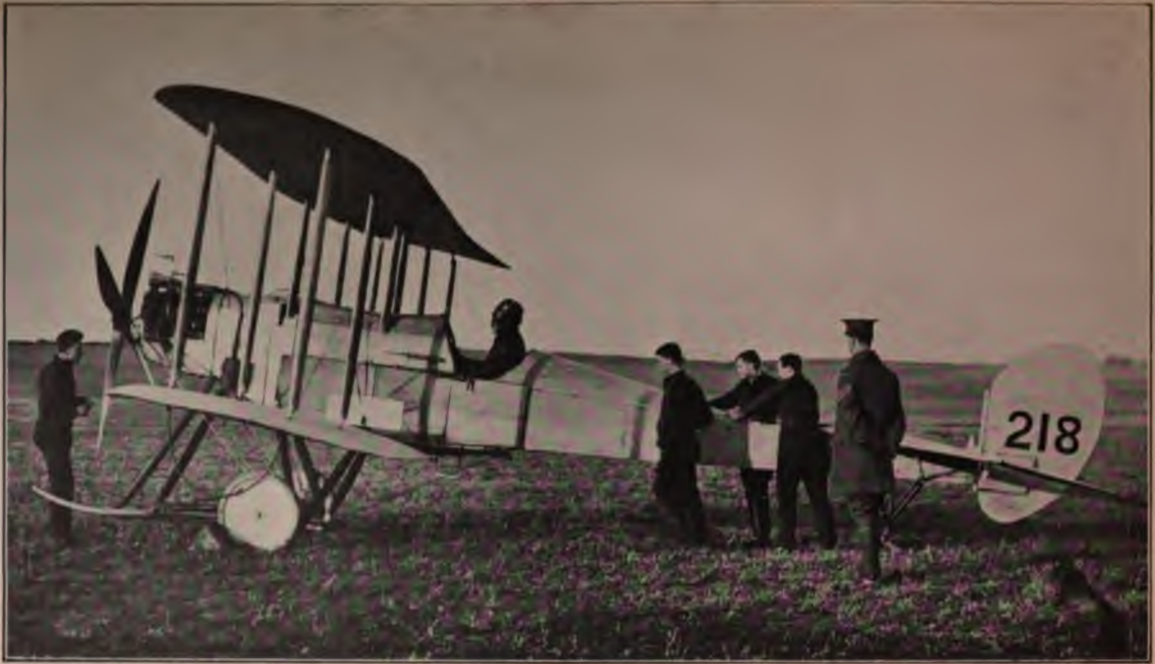

Photo: John M. Dunn]

CAPT. LONGCROFT, R.F.C., ON B.E. BIPLANE

Before starting on a flight it is necessary for a pilot to examine his machine in order to make certain that all is in order. Give your procedure for doing this on any machine you are acquainted with.

As the result of experience with a machine of the 'Baby' Grahame-White type, I should suggest the following method of rapid overhauling :

Controls.—This is the most important part. Examine lever or wheel and work various controls and note action ; examine connection between control wire and lever or wheel ; examine control wires, taking particular care to note any wear on parts passing through tubes and round pulleys ; examine connection between control planes and control wires, also hinges and fittings ; note any stiffness in working, also if fabric is secure and in good condition.

Main planes.—Examine wires, especially those near propeller, twang like a piano wire to test tautness. Note that wires are liable to break where bent to make a connection. Examine and tighten up, if necessary, all nuts liable to be loosened by engine vibration. Examine fabric for wear or tear. Any bend in the struts or main spars will be obvious.

Outrigging.—Examine framework, also tail planes in the same manner.

Landing skids and wheel spring suspension should be examined for loose wiring or rubber rotting. Any trouble like bent radius rods, bent wheel, or puncture is too obvious to need looking for.

Engine bearers, particularly holding down bolts, etc., should be examined; also note that all nuts on engine are tight, as such fittings as magneto may soon work loose. Examine carefully the petrol and oil tank fittings, as a loose petrol tank is very dangerous. Examine bolts on propeller and propeller itself, and then run engine for a few minutes to ensure good working.

All this may seem to take a long time, but in reality does not take so very long, and if, in addition, the machine is regularly overhauled, should greatly diminish the chance of accidents due to structural defects. Particular care should be taken to examine any parts that have been repaired, especially if recently.

Petrol and oil supply should be tested.

You have landed on a ground you don't know, and are heading straight for a ditch at some speed. What means have you for checking the speed of the machine:

(*a*) *In an aeroplane of the Farman type?*
(*b*) *In an aeroplane of the Blériot type?*

The methods of stopping aeroplanes when on the ground are as follows:

1. By some special mechanism—*e.g.* brake on wheels or raising wheels above skids.
2. Increasing head resistance by exposing extra surfaces as nearly as possible normal to the direction of flight.
3. Creating friction between some part of the machine and the ground without the use of a special mechanism.
4. Jumping out and holding on.

It is assumed that the engine has been switched off.

(*a*) Applying foregoing to a Farman type machine.
  (1) No mechanism is provided.
  (2) Considerable resistance can be afforded by working the flap lever violently from side to side, and at the same time similarly working the rudder to neutralise any sluing effect. The flap area on a Farman is considerable and the rapid working of the levers makes them almost as effective as if pulled down all simultaneously.
  (3) By raising the front elevator further resistance is added, and the back skid is brought into contact with the ground. As the Farman carries a considerable load on the tail this is pretty effective. If the elevator were thrown over rapidly, just after switching off, the machine would probably jump into the air, slow up and sit on its tail with disastrous results to that member, but with the speed effectively checked.
  (4) A Farman is too heavy to be held back by one man; besides this, owing to his position, it is practically impossible for the pilot to get out safely while the machine is moving.

(*b*) To a Blériot Monoplane.[1]
  (1) No mechanism is provided.
  (2) There are no surfaces of sufficient effective area to slow up by this method.
  (3) The small weight on the Blériot tail makes stopping by this method difficult. Merely depressing the tail by means of the elevator is hardly sufficient, and the pilot

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[1] See Notes on Landing, Chapter X. page 203.

climbs back along the fuselage, thus throwing considerable weight on it, and slowing up the machine.

(4) Owing to his convenient situation it is quite possible for a pilot to jump out and hang on to the machine, but still the performance is rather acrobatic and should be avoided if possible.

Under what circumstances would you suggest the trying of a propeller of less pitch on any machine you may be flying?

If the propeller is not giving sufficient thrust it may be that the slip is too great and the disc area too small. To correct this the diameter may be increased and the pitch decreased.

If the engine is giving less than its full revolutions the load is too great for it. The load may be reduced by reducing either the diameter or the pitch or the blade area. In all probability the change required would be a combination of the above, but depends on the particular requirements of the machine. Merely decreasing the pitch might mean that the thrust would fall off too rapidly as the speed of advance increased.

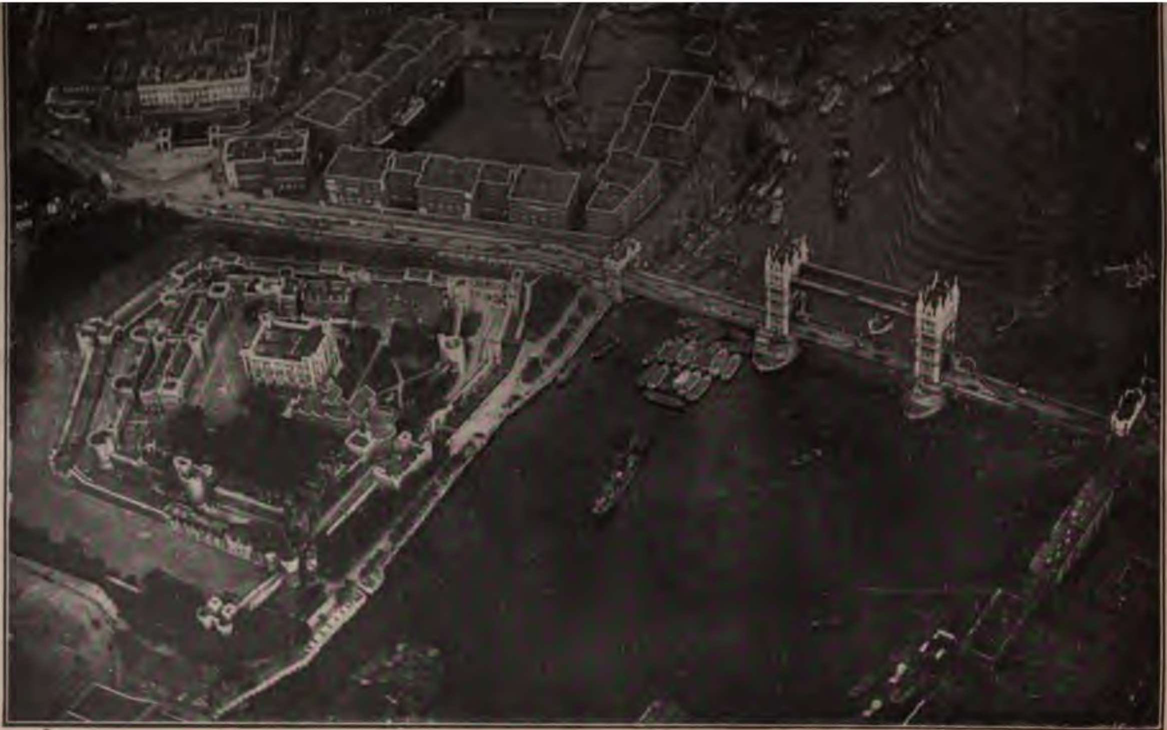
Under very special circumstances where the density of the air is very high owing to rise of pressure or fall of temperature, or possibly by excessive humidity, the speed of the machine may be lower than usual, and consequently a smaller pitch propeller might give greater efficiency.

CHAPTER III

ACCIDENTS AND THEIR PREVENTION

THEORETICALLY every flying accident is preventable, but, in practice, it has been unavoidable in the nature of things that numerous accidents have occurred, and it cannot for a moment be expected, even with the extensive knowledge of the conditions of flying now possessed, that they will, for a long time to come, be altogether avoided. Theoretically, it ought now to be possible by structural improvements in the machine, and by the exercise of strict caution in the selection of pilots, excluding all whose skill and character will not prevent them from making mistakes or render them proof against the temptation to fly when they ought not to fly, to ensure an almost absolute cessation of accidents. It is, however, impossible to regulate matters so perfectly. Even in railway travelling and marine navigation disasters are fairly common. In the first few years of railway work the death-rate was terribly high ; and what it must have been when men first confided in the frail boats of early times one can only imagine. Aerial navigation is now in much the same position as marine navigation was three thousand years ago. The moods and movements of the atmosphere are as little known from practical experience as were the moods and movements of the ocean known to the first navigators. The craft with which men travel in the air will bear about the same relation to air-craft of fifty years hence as the primitive man's coracle or canoe bears to the ocean liner of to-day.

By far the greater number of aeroplane accidents are due to precisely the same circumstances that have caused previous accidents. A distressing feature of these accidents is the evidence they afford of the unwillingness, or the inability, of many pilots to profit from the experiences and mistakes of others. Day after day men fly neglecting the most elementary precautions. Now, the best aviator is he who foresees all the possibilities of accidents and guards against them as far as is possible. He may not quickly leap into fame as a hero of the air, but he will become the soundest flyer, and he will do far more service to aerial navigation than a score of men who have simply thrown their lives away. There is, be it said, one factor in the situation which makes it impossible for any man altogether to guard against the possibility of mishap. No one knows yet precisely what strain a machine is subjected to when flying in all conditions of the atmosphere. Over and over again the liberal factors of safety allowed by careful constructors have proved inadequate. The laws of air pressure, as well as the capacity of disturbed air for giving violent shocks, are not yet completely understood. But in the first few years of flying the art has progressed at such a headlong pace, machines being called upon to carry heavier and heavier loads, at ever increasing speeds, venturing out now in high and gusty winds, that it is astonishing, not that accidents have been so many, but that they have been so few. All this advanced flying is being made, it must be remembered, upon machines that are not radically improved over the early Wright and Farman



TOWER BRIDGE AND THE TOWER

(Taken by Mr. W. J. S. Lockyer, on July 6, 1908, at 5.24 P.M., from the balloon 'Corona,' at a height of 2,300 feet)

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biplanes, and the Blériot and other monoplanes, with which pilots of four years ago would not venture to ascend when a leaf stirred, and could not fly at much more than fifty miles per hour.

By the exercise of common prudence by manufacturers, mechanics, and aviators, the number of flying accidents could be immediately diminished. The reports of the Public Safety and Accidents Investigation Committee of the Royal Aero Club bear testimony to the triviality of the causes of many fatal accidents, and every pilot could relate, out of his experience, a number of what might have been serious incidents caused by small and absurd oversights. Yet the lesson never seems to be learned; pilots are incredibly careless and casual, and they leave far too much to their mechanics; and manufacturers have, at times, been rather apt to sacrifice the vital elements of safety in their endeavour to attain some small point in speed or load-carrying quality. As an example of carelessness that might have led to an accident may be quoted an incident in the aeroplane race round London in September 1913. The winner,[1] flying a racing machine, which required more vigilance on the pilot's part than slower craft, had an unpleasant and dangerous experience, when still forty miles from home, through his petrol tap falling off. This was caused by the working loose of a screw, and the effect was to flood the machine with petrol which dashed into the pilot's face, embarrassing him, and threatening to bring his flight to a speedy termination from loss of fuel. Only by keeping a finger over the hole could the escape be stemmed, and the journey continued. This was calculated to cause a disastrous landing to any but an experienced pilot, and there was grave danger from fire. The incident points to the need for thorough examination of every part of the machine before a flight. It should be impossible for a petrol tap to work loose, and the obvious way to prevent it is to have a lock arrangement or, simpler still, to bind it with a strip of plaster. In the taking of precautions of this kind the late Mr. S. F. Cody gave a good example, he always bound his petrol tap, and locked every bolt of his engine, by drilling a hole and binding them with wire. So terrible may be the consequences of carelessness in any of these details, and so much damage has been done to machines, apart from questions of personal injury, by the neglect of trivial details, that the continued carelessness of aviators is extraordinary. It cannot be too often laid down that the best pilot is not he who exhibits great audacity, but rather the man who makes sure of his goal by preventing the possibility of mishap. By vigilance on the part of all concerned flying can be made safe even on the machines of the present day.

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[1] G. H.

One or two accidents have been caused by the slipping of the pilot's feet on the rudder bar owing to the presence of oil on the bar or on the shoes, or to the numbing of the lower limbs through cold. Yet rudder-bars are still usually made without any contrivance by which slipping could be absolutely prevented, and rubber, which is the worst possible material for the soles of an aviator's shoes, is still worn.

Mr. Hawker's accident, which terminated his attempt to fly round Britain on a hydro-aeroplane in 1913, was due to the almost absurdly trivial cause of his foot slipping on the rudder-bar. Hawker said afterwards: 'We were 600 feet up, and I started an ordinary descent—a right turn to alight against the wind. When within fifty or sixty feet of the water I began to "straighten up" for the landing. To my dismay my left foot slipped off the rudder-bar; that threw my right foot hard forward; the machine turned sharp to the right, and there was no room left before we touched the sea to correct the fault. We screwed right round, struck the water half sideways and half backwards on an even keel. That was the end of it. The floats were torn completely off. The machine was held up by her wings: she did not touch bottom. If only I could live those ten seconds again! The accident was as simple as slipping on a banana-skin when you are running to catch a train, or being bowled by an easy one when you feel good to hit for the rest of the afternoon. I did not feel the slightest shock. Nobody was more surprised than myself to find that Kauper was hurt. We had been talking to each other, on quite ordinary affairs, as we came down.'

A few weeks later Mr. Brock was flying at Hendon when, owing to the heel of his boot being clogged with mud, his right foot slipped over the rudder-bar and he fell forward on to his left foot. The rudder came hard over, the machine did a sharp turn, banked up on the right till it was almost vertical, side-slipped, and then, the rudder acting as an elevator, dived steeply. Mr. Brock pushed himself back in his seat, got his right foot on to the rudder-bar and straightened the machine out about fifty or sixty feet from the ground.

No matter how good and experienced his mechanic may be, the pilot should see for himself that everything is in order. Mechanics have been known to leave a spanner on the lower plane of a biplane, and on the machine taking flight the tool has rolled over to the back, and come into contact with the propeller, causing the latter to fly into fragments to the imminent danger of the pilot and bystanders, and in any case compelling an immediate descent. On one occasion Mr. J. A. Drexel, starting on a cross-country journey, found on rising from the ground that his elevator had been coupled up the wrong way, with the result that, when he pulled the lever to ascend, the machine promptly dived. The machine was wrecked. A man hanging on to the tail to hold a machine still before the start, distorted the elevator so that when the pilot[1] got away he found the machine persistently canted up on the right. A double fatality[2] was caused, in September 1912, by the working loose of a quick-release device of one of the cables supporting a wing, through the stress of the corresponding cable of the opposite wing, and it is surmised that the loose cable striking the wing rent the fabric, with the result that very rapidly the wing began to disintegrate. Obviously a quick-release attachment should be so contrived that it cannot release itself through vibration or through any other cause. One fatal accident was due to the literal rotting away of the fabric of the wings and elevator, the result being that the machine—a Cody biplane—went to pieces in the air, and the pilot was killed. Aviation, of course, has called into use new mechanical contrivances in which new materials are employed; and, as already explained, the amount of strain to which the apparatus is subjected was for long underestimated. Nevertheless the fact that very frequent overhauling of machines was not made before numerous fatal accidents taught the lesson is matter for astonishment. Pilots using the Gnome engine too often fail, before making an ascent, to see that the **C** springs holding the rocker on the exhaust valve are in place on each cylinder. They readily become displaced, in which event there is great risk that a rocker will fall out in flight. It is easy to slip them into the

[1] G. H.

[2] Lieuts. E. Hotchkiss and C. A. Bettington.

right position with the fingers, for they merely have to be turned round until they slip into their groove. Mr. Morison was brought down by this means almost at the outset of the Circuit of Europe race in 1911, when he had to make a hurried descent a few miles from Paris. It is easy for the mechanic to overlook a little thing like this, and it is not improbable that on occasion it has been done out of spite by some person nursing a grudge against the flyer.

After the fatal accident by which Mr. Cody and his passenger were killed, it was demonstrated that the aeroplane failed owing to inherent structural weakness. In this case it is highly probable that the designer of the machine, which had a much greater span than any he had previously built, did not make sufficient allowance for the multiplied strain on the wings. This was an oversight readily explainable by the fact that all designers had been working more or less in the dark in certain directions. Shortly before this accident occurred, Prof. Petavel demonstrated that the greatest suction on the top of the planes is at the rear end of the extremities, the upward pull always being in excess of the pressure below the plane. Sudden alterations of the engine power in flight, quick manœuvres, and gusts and eddies of air must, moreover, put an enormous pressure on the wing tips.

In the spring of 1912 a long succession of monoplane accidents caused so much uneasiness in France that the military authorities prohibited monoplane flying, and instituted an inquiry. M. Louis Blériot, at about that time, put forward the theory that in certain conditions in flying the pressure of the air is transferred from the bottom of the wings to the top, and there was, indeed, some evidence to show that machines had broken in the air by the wings collapsing downwards. Soon afterwards all the monoplanes in the French Army were structurally modified, and thereafter the number of accidents due to breakage in the air diminished.

Even experienced pilots at times exhibit extraordinary recklessness and lack of judgment. It requires moral courage to decline to fly in fulfilment of a promise, but flying being an occupation in which a trivial cause may have a serious effect, moral courage is one of the necessary parts of an aviator's character. Yet many a man, feeling slightly out of condition himself, or discovering that his motor is running weakly, attempts a flight in the hope that the human or the mechanical engine, as the case may be, will recover after a few minutes in the air. In calm weather and over the aerodrome little harm is likely to come from such ventures, but across country in bad weather the danger is tremendous. One lesson in this precaution is provided by the fatality to Lieut. Wilfred Parke and his passenger. They ascended at Hendon on December 15, 1912, and although the engine was running so badly that the aeroplane laboured along tail down, they left the limits of the aerodrome for the country. The wind was very high and gusty, so much so that no other aeroplane ventured aloft. When over Wembley Golf Links, Lieut. Parke, presumably convinced that it was not possible to carry on, turned the machine about towards Hendon. He was at the time no more than forty feet above the top of a belt of trees, and so experienced a pilot must have been perfectly well aware that he was undertaking a very risky manœuvre, the wind blowing at right angles to the belt of trees. In turning there is always some loss of lifting power, which in the case of a weakly-running engine, is very marked. In this instance the machine became the sport of the wind; and, owing to the configuration of the ground and the belt of trees at this particular point, it was quite certain that the successful accomplishment of the manœvure would be a matter of luck. The aeroplane was seen to turn to the left and across the belt of trees. It then drifted along, perilously low, on the lee-side for about 120 yards and fell head first.

It is the inexperienced pilot who takes the most absurd risks, and it cannot be too insistently drilled into a pupil that in the event of his engine showing the slightest sign of faltering, he should land, and that in a cross-country journey with an engine showing any inclination to fail his first thought must be to reach a good landing place.

It was for long the popular impression that accidents were due largely to buffeting by the wind, but it is highly probable, if it were possible to make an exhaustive analysis of all the aeroplane accidents that have occurred, it would be found very few fatalities have been due to the wind. Indeed, nothing is more remarkable in the history of flight than the rapidly increasing confidence of aviators in bad weather. Give a good pilot a good machine and a sound engine and he will fly in any wind up to a gale, fearing nothing all the while he maintains sufficient altitude in which to recover lost balance. Skill, however, is required in landing, especially should the engine be running weakly.

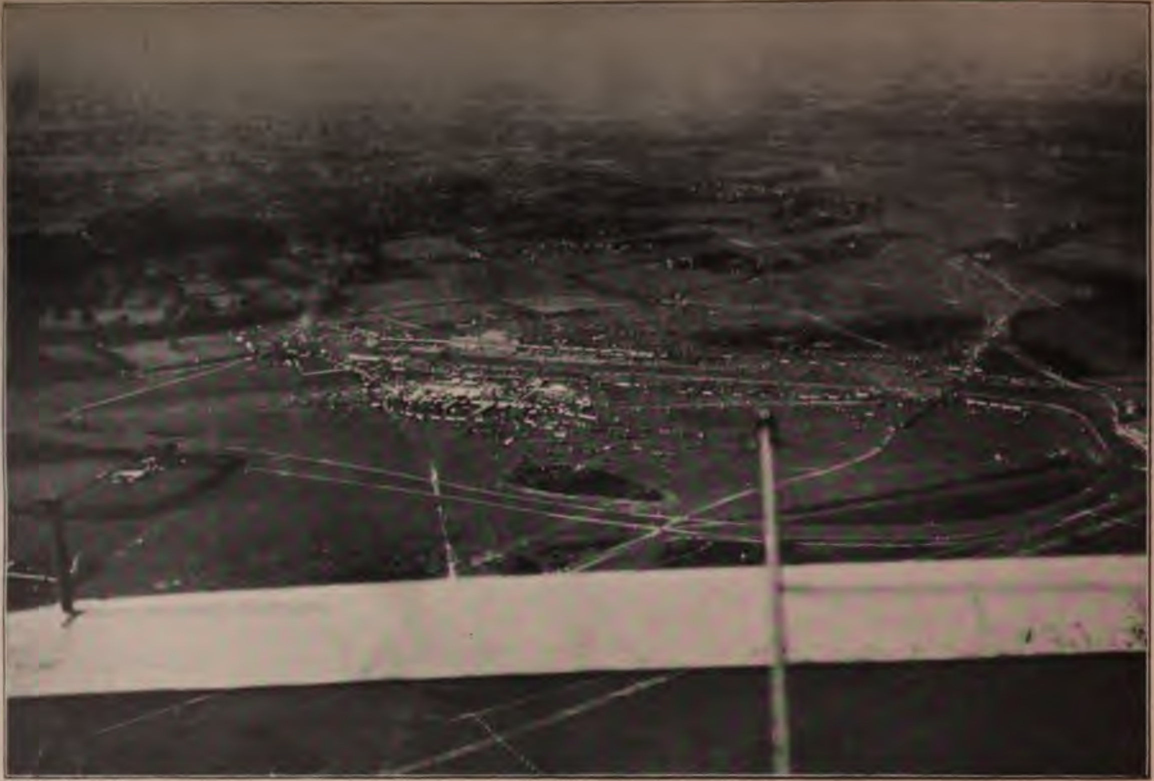
A machine may be caused to side-slip by clumsy piloting and by being turned over by the wind, and in the early days side-slips were by no means rare owing to the imperfect engines then in use. In those days pupils were really called upon to face perils which would appal the experienced pilots of to-day. They flew with imperfect craft, and they knew little of the art of aviation.

But it soon became easy, at a well-appointed school, for a pupil to undergo his training and obtain his certificate without experiencing the real dangers and hardships of flying. This blissful state of affairs was partly rendered possible by the introduction of the Gnome engine, which was far more reliable than any of its rivals.

Side-slipping, nevertheless, was for long the bugbear of pilots and in some measure very properly is still wholesomely dreaded, although even in a pronounced case the pilot can, if he has plenty of air-room, bring the machine into a safe position. Many have been the theories put forward to show how it can be corrected. Aviators, indeed, deliberately brought about side-slips and tail and head dives in order to find out the remedy. One of the most interesting practical experiments was made by Mr. Orville Wright, and is described in a letter from Mr. Griffith Brewer to Mr. Alec Ogilvie.

'Orville has been going into the cause of a number of accidents where, for some unexplained reason, the machine has suddenly pointed downwards and has not been corrected before coming into contact with the ground. This type of accident has occurred in several cases after gliding down from a considerable height, and after being straightened out at perhaps fifty feet from the ground the machine is seen to turn downwards and to continue to turn down until it strikes the ground. In some cases such accidents have been attributed to the fouling of the control wires, but in an inquest held by the American authorities on the wreck of an army machine the control wires were found to be intact.

'The conclusion that Orville has come to is that these accidents are caused by the stalling of the machine, and he has been making experiments in the air in order to test the effect of stalling in actual practice. He went to



'Daily Mirror']

EPSOM RACE-COURSE ON 'DERBY' DAY FROM AN AEROPLANE.

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the height of 300 feet, and stalled the machine, and, as he had expected, the machine turned slowly downwards, and for a period of at least five or six seconds after first stalling, the elevator tail was useless and the moving of the lever had no effect on the inclination of the machine whatever. The machine pointed downwards at a very steep angle, possibly 60°, before it had gathered sufficient speed to bring it under control. Instead of dropping fifty or sixty feet in this recovery, however, he dropped about 200 feet before he could straighten her out, and he says that he did not stall her to the worst position possible, and he would not be surprised if it would be necessary in some instance to have 300 feet clear below to enable the stalling to be corrected in time to save a smash.'

Mr. W. B. R. Moorhouse on one occasion forced the head of a Blériot monoplane up as far as it would go, and cut off his engine with the object of sliding down tail first by way of experiment. The machine stood still on end, then turned slightly over sideways and dived, and the pilot landed without damaging it. M. Adolphe Pégoud introduced side-slips, tail-dives, and nose-dives into his exhibition repertory of flying. English aviators have shown that a machine can fall plumb for many hundreds of feet tail down or sideways, and can then be brought to a level keel for landing.[1]

There is an impression in some quarters that propeller biplanes of the lifting-tail order are prone, if 'stalled,' to dive tail-foremost to the ground. In practice this is not the case when the machine is at a higher altitude than about 100 feet. Such a machine will tail-slide for a short distance, side-slip about as far again, and then dive head-foremost, so that if the tail-slide occurs at a sufficient height, the machine can be brought to a safe altitude for landing.

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[1] Mr. B. C. Hucks, G. H., and others.

With a view to the prevention of accidents it is of the utmost importance that a pilot should know what to do when his machine gets into a dangerous position. The first essential is that he should retain his presence of mind. The worst situation can be overcome, and the advance in the art of flying is in a large measure the increasing realisation of this fact. Different types of aeroplanes behave differently, but one thing applies to them all, and that is, to recover from side-slips all that is necessary is to turn the side-slip into a nose-dive, after which it is only a question of having sufficient altitude in order to be able to resume control over the direction and attitude of flight. The tractor monoplane will quickly take the diving position. Engine-behind machines, on the other hand, should be brought to that position by the pilot. Unfortunately, of course, a side-slip may begin when the aviator is not at a great altitude, if caused by air disturbances, which are more pronounced near the ground than in the upper regions. Only experience, however, can teach the aviator how to avoid running into trouble of this kind. A few weeks before his fatal accident, the late Lieut. Parke, carrying a passenger, had a memorable side-slip and dive, from which he recovered only at the last moment. He remembered with apparent accuracy every moment of that experience, and he has related all that he did to bring the machine level. He was flying against the wind on an Avro biplane, capable of a speed of sixty miles per hour, and the engine was working well. At a height of about 700 feet the pilot throttled down the engine with the intention of making a spiral glide. Having completed a half spiral Lieut. Parke thought the machine was in an unnecessarily steep attitude and was insufficiently 'banked' for the turn. He therefore elevated, and proposed giving a slight touch to the warp with the object of reducing the steepness of the descent and increasing the 'bank.' The machine at once started a spiral nose-dive. 'Then,' says the account of this incident which appeared in *Flight*,[1] 'Parke opened the throttle in the hope that the propeller might pull the nose up. This failed to have the desired effect, but obviously it may have accelerated the rate of descent. He drew the elevator lever back and put the rudder hard over to the left in order to turn the machine inwards. The machine was then completely out of control, and was diving at such a steep angle that the onlookers described it as vertical and gave up hope. Parke said that the dive was not vertical, but was certainly very steep. His right hand was now off the control and grasping a strut to prevent himself being thrown outwards by the spiral motion of the machine. He felt no undue pressure on the legs and arms. His next manœuvre was to push the rudder hard over to the right in order to turn the machine outwards from the circle in which it was diving, and now the machine promptly straightened and flattened out, came under perfect control, and proceeded in the normal flight attitude. At the moment it recovered, its distance from the ground was only fifty feet.'

For some time after the publication of this incident, discussion proceeded on the question of the proper way of recovering from side-slip. At that time the biplane pupil was usually told that to correct an incipient side-slip it was necessary to bring the head of the machine down to gain speed, and, at the same time, to rudder away from the side to which the machine was slipping.

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[1] *Flight*, August 31, 1912.

That is to say, if the machine was slipping down to the left with the right wing uppermost, the pilot should push the lever forward and at the same time push his right foot forward in order to steer to the right. This method is usually successful, although when the side-slip becomes pronounced and the machine is at no great altitude, the ground may be encountered before the pilot has got his craft under control. But apparently the matter is not quite so simple as this makes it appear. Different machines behave in different ways. When a monoplane turns over sideways, after a slip of thirty or forty feet, as a rule, the machine turns of itself head down, when it is a simple matter to obtain steering way. It is possible to recover from a side-slip not by turning from the circle but by turning inwards, the effect of which at first is to increase the steepness of the 'bank.' But whatever method may be employed, the end in view is to get the head of the machine down and to obtain sufficient velocity for the elevator to have effect and straighten the machine out.

On the theory that the correct way to overcome side-slip is to turn outwards and warp against the tilting, it is necessary to remark that the effect of warping may be to drag the machine back on the near side instead of lifting the lower wing, so that warping alone may be a dangerous proceeding. It can only be safe when the machine is getting sufficient way on it to make the simultaneous steering outwards effective. Machines with closed-in bodies or with vertical fins, no doubt, behave in side-slips differently from machines with open fuselages and machines with little or no vertical surface, and the shape of the closed-in bodies is also influential. Designers have to some extent taken this into account, and pilots of machines with exceptional depth of closed-in body utilise this feature when going in for close manœuvres. There may be a field for originality of design and for useful development in this direction. There is, probably, a difference between the behaviour of tractors and of propelled machines, and between machines with forward elevators and those without. Machines with large forward elevators, or with elevators consisting of two cross-connected parts acting oppositely, should be very controllable.

The question of the effect of dihedral-angle wings and the employment of fixed vertical fins is raised in this connection, and it appears highly probable that if the individuality of inventors and designers be given free play, remarkable developments will ere long be seen in the following directions: The use of closed-in bodies, the sides of them formed with a view to effect on stability; the provision, to a far greater extent, of fixed vertical surfaces; and the employment of variable-angle and variable-area plane surfaces.

In the reference to the corkscrew descent, in Chapter X. page 193, it is explained, that, with a machine upon its side, the elevator becomes in effect the rudder, and the rudder plane then being horizontal operates as an elevator. This circumstance clearly affects the operations that a pilot must make in order to recover from a pronounced side-slip. Failure to recover from side-slip may, in some cases, have been due indirectly to the pilot overlooking the fact that in a machine in that attitude the elevator and rudder have changed functions. Tilting the elevator upwards or downwards in this case results in turning the machine to right or left. Here the value of practising the corkscrew descent is seen. It stands to reason that a pilot who is thoroughly familiar with this movement, so that he is not alarmed when the machine gets on its side, will have a far better chance to recover than the pilot to whom it seems that excessive tilting up of the machine is the inevitable prelude to disaster.

Over and over again, one is made to realise the immense importance of being free from panic. Presence of mind has saved aviators scores of times from disaster. In April 1911, the late Mr. H. J. D. Astley was turned over on his left wing tip by the wind. He switched off his engine and let the machine dive, which was quite the proper thing to do; but, as he related afterwards, accidentally during the dive he moved the switch on again and the sudden jerk, caused by the starting of the engine, threw him out of his seat on to the fuselage to which he found himself clinging by holding on to the cabane. The moving of his weight aft had the effect of bringing the tail down, so much so that the machine headed upwards at a very steep angle. This, he said, gave him time to crawl back into his seat and resume control, and he managed to make a fair landing. Even in the case of a machine breaking in the air a pilot has one small chance of saving himself. Mr. Gordon Bell, flying an R.E.P. monoplane, saw one of the wing-stays break, with the result that the whole of that wing bent upwards and threatened to collapse. This was at a height of 4,000 feet, yet the pilot brought the machine down without mishap, his one consideration being to put the injured wing to as little strain as possible. In the case of the accident to Lieuts. Hotchkiss and Bettington, already referred to, it was suggested that, had the pilot brought the machine down on as gradual a glide path as possible, the wings might have stood the strain. Instead, on observing them begin to break up, his one concern was to reach earth quickly. He headed down rather steeply, and the great velocity of the machine destroyed all chance of saving

HERNE BAY
(Taken by Miss Trehawke Davies, passenger with G. H.)

NEAR MARGATE
Taken by Miss Trehawke Davies, passenger with G. H.)

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the wings. The value of practising not only ordinary manœuvres, but what is commonly known as 'trick' flying, has already been remarked upon. Flying upside-down and describing vertical loops in the air must, if properly prepared for and considered, render the pilot more capable when put into situations of danger.

Capt. Reynolds had an extraordinary experience during a flight from Oxford to Cambridge, in August 1911. Near Bletchley he saw a big, black thunder-cloud coming up on his right front. Quoting from his own narrative :—
'It did not look reassuring, and there was a good landing ground below. At this time I was flying about 1,700 feet altitude by my aneroid, which had been set at Oxford in the morning. I began a glide, but, almost directly I had switched off, the tail of the machine was suddenly wrenched upwards as if it had been hit from below, and I saw the elevator go down perpendicularly below me. I was not strapped in, and I suppose I caught hold of the uprights at my side, for the next thing I realised was that I was lying in a heap on what ordinarily is the under-surface of the top plane. The machine in fact was upside-down. I stood up, held on, and waited. The machine just floated about, gliding from side to side like a piece of paper falling. Then it overswung itself, so to speak, and went down more or less vertically sideways until it righted itself momentarily the right way up.

'Then it went down tail first, turned over upside-down again, and restarted the old floating motion. We were still some way from the ground, and took what seemed like a long time in reaching it. I looked round somewhat hurriedly, the tail was still there, and I could see nothing wrong. As we got close to the ground the machine was doing long swings from side to side, and I made up my mind that the only thing to do was to try and jump clear of the wreckage before the crash. In the last swing we slid down, I think, about thirty feet, and hit the ground pretty hard. Fortunately I hung on practically to the end, and, according to those who were looking on, I did not jump till about ten feet from the ground.

'I was told that just before I smashed there had been two or three "whirlwinds," as the people called them, in Bletchley, and that one of these had stripped the leaves off a tree.'

One of the most distressing possibilities in flying is fire, either in mid-air or when breaking out on a wrecked machine under which the pilot is pinned. This danger is capable of being entirely removed by the observance of a few simple precautions. The most frequent cause of fire during flight is back-firing due to the improper closing of the inlet valve. In this case the pilot must immediately switch off his engine and come down, and he then has a very good chance of escaping serious consequences even though he has a long distance to descend. In a style of construction now practically obsolete the carburettor is situated under the tank. In this case the breaking of an inlet valve causes flames to jet out. Every time the charge in the cylinder containing the broken valve fires, the whole of the mixture in the crank chamber fires and explodes, blowing back through the induction pipe. Then, if there be a leak in the tank, the situation becomes critical. It is now the usual practice to have the carburettor in front, which obviously reduces this danger. It used to be supposed that the air-cooled engine was more dangerous than the water-cooled engine as regards the outbreak of fire, but there is no support for an idea which must have been based on the absurd supposition that escaping petrol can easily become ignited merely by contact with a hot engine, and without the intervention of a spark.

The construction of aeroplanes is becoming sounder every year, but even to-day it is not uncommon to see a machine carrying very flimsy brass or copper petrol tanks most insecurely held in their place, the pipes also being of a quality that ensures their early breakage. The tanks ought to be made of steel, the slight increase of weight being a relatively unimportant consideration. The pipes should be made of flexible armoured tubing. The necessity for stout and securely fixed tanks arises in flight, but even more when, in landing, a machine gets a bad jar. Many an accident, which would have been no more serious in effect than the breaking of a part of the aeroplane, has been turned into the complete destruction of the machine and the pilot, for the simple reason that the tank has burst and the petrol has become ignited. Certain elementary rules are to be observed by pilots. One is, instantly to switch off the engine when a bad landing is inevitable. For one reason, with the engine stopped, contact with the ground will be less violent. Then, again, if the engine be running and the pilot or the passenger, whoever may be in front, be pitched forward out of his seat, he may conceivably be in danger of having his limbs torn by the rotating motor—assuming that a rotating motor is used. But in the case of a bad landing the petrol tank is very likely to burst, and if sparking continues a blaze is almost inevitable. Most pilots, at any rate in the early days, saw examples of almost incredible folly in this direction. Pupils side-slipping to earth or coming down nose first would omit this one vitally important precaution of stopping the engine, so that many a man owed his escape from a dreadful death purely to chance, or else to the fact that the onlookers were able to extricate him from the wreckage before the fire reached him.

Safety in flight depends, to an enormous extent, upon being able to make a fair landing under difficult conditions. In the ordinary course of tuition pupils are not given sufficient training in landing. One essential is to have a landing place always in mind, a place within range of the gliding path of the machine. When at a great altitude the airman has more time to select a good landing place than when he is below 2,000 feet, in which case he must make his mind up instantly and not change it. It is a great advantage to be able to make a sharp spiral, for in doing that the pilot can take into his view the whole of the country below him, and not merely that section of it which lies in front. Having made the spiral he can head for the best spot available. Between the best spot available and the worst there may be all the difference between a wrecked machine and perfect safety. In a country like England which is, for the most part, cut up into small fields and is thickly populated, an aviator flying at a low altitude has often little choice of an alighting ground. He must be able to learn how to make a fairly safe 'pancake,' for it will often happen that he has only a small field, and that the ordinary run along the ground would land him into a fence or a hedge. In thickly wooded country there have been occasions when aviators have been compelled to come down on trees, and the only way to do that with the slightest chance of escaping damage is to exhaust the velocity of the machine and when within about ten feet of the tops of the trees fall flat; there is a possibility then that the machine will be held up with the pilot in the seat.

It is often difficult to tell from overhead the nature of the ground. What looks like smooth grass seen from a height of 2,000 feet may turn out on closer inspection to be hillocky and seamed with ditches, but by the time the airman has ascertained the nature of the trap it is too late for him to avoid it, he must in that case know how to make a 'pancake' landing. It is not difficult to land in growing corn, or even among cabbages, or clover, but very dangerous is light soil of the kind in which usually beetroot is cultivated. In this soil the wheels plunge deeply and there is risk of the machine turning completely over. Ordinary ploughed land is comparatively easy to land in and get off from.

In no circumstances should an aviator throw himself out of the machine in a bad landing. In nearly every case, so much is there to break in the way of fuselage and undercarriage before any injury is done to the pilot, that he has a far better chance of escaping scot-free than if he throw himself out at the last moment, even though he has had the acrobat's training and knows how to fall after the manner of the knockabout artist at the circus, who laughs at tumbles which would break the bones of the average man. The question of the wearing of straps or belts to hold the pilot in his place enters here. While it must be considered advisable to be strapped in, some instances could be quoted showing that the pilot's life has been saved by the mere fact that he was not strapped. His escape with a few bruises from a bad smash in the Gordon-Bennett, at Eastchurch, in 1911, caused the aviator[1] for some time after to decline straps. Had he been strapped in on that occasion he would probably have been killed outright, for he would have been pinned down under the wreck in which, it may be remembered, the motor buried itself two feet in the ground, or he would in any case have been seriously injured. The straps usually worn consist of an elastic belt passed round the pilot and attached to the fuselage. They prevent the pilot from being shaken out of his seat when the machine is rocked about violently by gusts and eddies. In most machines, however, the latter danger is not very pressing, because the pilot has hold of the cloche, or the lever, and can grip himself in with sufficient security. In some machines straps are more necessary than in others. For example, in the Blériot monoplane, and aeroplanes of similar general design, the machine in normal descents takes up an attitude that is not steeply inclined. On the other hand, certain types of machine designed like the Morane-Saulnier and the Nieuport even in horizontal flight have their tail very high; then in a vol plané the pilot's seat becomes very tilted and there is a tendency to be thrown forward, although, as a matter of fact, the machine may be gliding down on a beautifully gradual path.

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[1] G. H.

By remaining in their seats pilots have survived the complete wreck of a machine without a personal scratch. In the opinion of the experts who examined the evidence relating to the fatal accident to Mr. Cody, the pilot and the passenger, even in this case, would have saved their lives had they been strapped in. Others who might have been saved by straps were the late Majors Merrick and Hewetson, Lieut. Desmond Arthur, and Messrs. Fisher, Mason, and Fenwick. Scores of cases could be quoted showing the great amount of damage that can be done to the machine before the pilot's person is touched, and it seems reasonable to suppose that one of the considerations in the mind of the designer of the future will be prevention of injury to the occupants of the machine in the case of total wreckage. A machine can fall thirty or forty feet like a stone, and the undercarriage may be completely smashed to pieces, the pilot feeling no more than a bad jar.

Flying at Bangor on one occasion, a pilot[1] started off against a strong wind and headed for some trees intending to get up high, do one complete circuit, and then descend, a large crowd having collected by the promise of an exhibition. Beyond the trees the ground sloped up to the mountains, and the wind was sweeping down the mountain side over the trees against the aviator. Owing to this there was great difficulty in climbing, and when about level with the tree-tops the machine was making scarcely any forward progress and was not rising at all, but it was pitching about considerably. It was caught in the down current that swept over them and was irresistibly borne down at the very moment the pilot decided a landing was inevitable. The machine dropped plumb forty feet, but landed quite flatly, and although the underpart of the aeroplane was completely destroyed, the pilot escaped with a few scratches. The use of wicker-work for the pilot's place has been suggested, and certainly the stout wicker of balloon baskets is extraordinarily tough and tenacious.

It has for long been a doctrine with many people that safety in flight depends upon a machine's capacity for speed, and that speed is practically a synonym for stability. There is no questioning the advantage of speed and of the power enabling the aerial traveller to forge against adverse winds, but mere speed means neither stability nor safety. Indeed, the latter are probably entirely due to design. Taking a machine of one type and applying to it engines of different power, it will be found that the low-powered machine is, so far as safety in wind gusts is concerned, as good as the high-powered one. A pilot who flies a 50 h.p. Blériot, and an 80 h.p., and 100 h.p. on occasion, will, after careful comparison, be as ready to go out in a high wind in the 50 h.p. as in the 100 h.p. This is practical experience. It has been said, and is at times still put forward, that a rule exists to the effect that an aeroplane is capable of weathering a wind of not more than a third of its own velocity. Thus an aeroplane that can fly at sixty miles should not be taken out in a wind of more than twenty miles per hour. This, in practice, is entirely wrong. As a matter of fact, a 50 h.p. aeroplane can be taken out in a wind of fifty miles per hour, against which it can make no progress, and yet by proper handling it can be safely manœuvred. A machine of double the power would be no more safe in the most skilful hands. But there is no doubt that very fast machines require more skill to handle them than comparatively slow ones. The movements must be quicker, the touch more delicate. And there was one factor which rendered the fast machines of early days objects of suspicion, and that was a question of structural strength. In its swift progress through the air the fast machine is subjected to more violent buffeting by gusts and eddies, although it may pitch and roll less than a slower craft, and the strain upon its wings and controls is very great. This, of course, is remedied by sound construction, but in the first keen struggle for increased speed construction was not improved proportionately. So much depends upon the skill of the pilot and the design of the machine that it is extremely unwise to attempt any generalisation on relations between speed and safety or stability.

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[1] G. H.

The pilot should avoid all abrupt movements with the controls. After steeply diving the flattening-out process should be gradual, for the machine has attained

'*Aeroplane*']

B.E. BIPLANE

'*Flight*']

AVRO BIPLANE

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a great velocity and any attempt to change its course suddenly subjects it to pressures for which it may not be designed.

In other chapters[1] brief reference is made to the nature of the instruments that ought to be carried in flight. Among these, of course, are the compass, the pressure gauge, the revolution counter, and the air-pressure indicator, all of which are designed to ensure safety. What is known as the inclinometer is also mentioned.

The following interesting note on the question of accident prevention has been sent to the authors by one of the greatest practical exponents and deepest students of flying.

'Exclusive of genuine "accidental" accidents such as collisions, these may be classed under two heads:

'1. *Machine's fault.* Breakage or jamming of machine or control.

'2. *Pilot's fault.*
  (*a*) Lack of understanding what machine is doing.
  (*b*) Lack of understanding what pilot ought to do with machine.

'1. This is a manufacturing and constructional affair, which time and increased knowledge of the stresses entailed ought to eliminate.

'2. (*a*) My view is that instruments are better at showing what the machine is doing than a man's sensations, which are liable to mislead and which are not nearly well enough organised for the delicate operations involved in flight. What are required are instruments to tell the angle of incidence of the wing surface with regard to the air, the speed of the machine in the air, the lateral equilibrium of the machine.

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[1] See pages 39 and 127.

'(*b*) This will be improved by increased knowledge of the limitations of a machine: (1) as regards the safe angles of incidence between which the movement of the centre of pressure on the wing can be easily controlled by the elevator, so that the machine can always be righted; (2) as regards the safe speeds, within which the structure of the machine is perfectly sound; (3) as regards the lateral equilibrium; this is very far from being generally understood both in straight flight and during turns. My own view is that the rudder and the warp should be coupled together, as I am convinced of the necessity for simultaneous use.

'These remarks apply in the main to ordinary types of machines only, not to automatically stable machines, where the problem of control is different.'

DANGER IN AVIATION

BY HENRY FARMAN

Although the accidents in flying alarm the general public, I have no hesitation in affirming that, in the course of a very short time, aerial navigation will be no more dangerous than any other means of transport. So far as theory can go it is a simple matter to prove this.

In the first place a well-made flying machine of one of the existing types is, while in the air, in no danger even if badly steered. The various and, at first, bold experiments made by M. Chevillard on the Henry Farman biplane and by M. Pégoud on the Blériot monoplane prove that whatever the position a machine may be thrown into it is controllable and can be brought back to its normal flying attitude. Consequently if a machine be turned over by a violent gust, there is not the least danger provided that the pilot knows how to handle it. It is, however, extremely doubtful whether any aviator has ever been up in a squall strong enough to turn his machine right over. This is not an impossible situation, but having admitted it, I maintain that a good pilot with a good machine has no cause to fear.

The good machines are in existence. For their work they are stronger than automobiles: they have a bigger factor of safety. Unfortunately, however, the materials of which they are made are sometimes subject to rapid deterioration, and in that real danger lies. The cases of the breaking of parts in the air are exceedingly rare and will soon entirely cease. There are many good pilots, but in the course of a few years these pilots will appear in the eyes of the pilots of that time to be no more than mere novices, so greatly will the art of piloting have improved. And let it at once be understood that with the improvement of the best pilots the average pilot's skill improves and the difficulties of the beginner diminish. These are factors that make powerfully for safety.

Let me repeat there is no danger in the air.

The starting of the aeroplane is another matter. Here danger exists in some circumstances, but this danger is only risked by the unwise. For example, there is great risk in starting out of a small ground surrounded by trees with a motor that is working defectively. A motorist who attempted to run down a steep hill with defective brakes would also be taking great risks.

In landing—on a flying machine—are found the greatest difficulties, but these difficulties can be almost entirely overcome, even at the present day, by the exercise of ordinary prudence, and they will entirely disappear when prudence is exercised, and at the same time when the machine is driven by an absolutely reliable motor. Flying at a height of 3,000 feet, or even at 1,500 feet, an aviator cannot tell whether the ground is quite suitable for landing. That being the case he is foolish to cut off his motor entirely, for having done that he must alight even though on closer inspection the ground prove to be extremely dangerous. The prudent aviator, therefore, does not cut off his motor until he is sure of his ground. But it sometimes happens that the motor breaks down, and then landing is compulsory and in the best fashion it can be made. In a field full of ditches or holes there is danger then of breaking wood and even capsising. The latter contingency, fortunately, even now with well-designed machines that can land at small speed, scarcely arises, for a fairly good pilot can so arrange matters that there is little or no run after first touching earth. Still, as matters are, landing is the one danger in flying and that because of the possibilities of engine breakdown.

In the near future engines will be far more reliable, and total breakdown will be unknown. Partial failure will even then be possible, but that would give the pilot time to choose his landing-place with some deliberation.

It is scarcely reasonable to expect perfection in flying machines yet. The breakage of axles in motor-cars and railway trains is not unknown.

With more reliable motors flying will be so safe and the knowledge of flying and the necessary prudence so common that practically it will have lost all its riskiness, even in the view of those who are now most impressed by the number of accidents.

It will be so safe that we shall hear no more of the need to carry parachutes or other safety devices, for the contingency of having to abandon the machine in the air will seem an absurdity to contemplate.

PARIS, *November* 5, 1913.

CHAPTER IV

CROSS-COUNTRY FLYING

To be able to travel from any one place to another in a straight line, and to be able to ignore the boundaries of sea and land, and the obstruction of mountains, rivers, and forests seemed to the imagination of early aeronautical authors to promise ideal navigation. The idea of being lost in the air probably never occurred seriously in pre-flying days. How could an aerial vehicle be lost when so much of the earth's surface could be seen by those on board? Balloonists, the first human beings to travel through the air, had, it is true, drifted past localities known to them and had been unable to identify their position by the map, but it was considered that with a motor-driven air-craft, equipped with compass and provided with maps, finding the way would be the easiest thing in the world. Practical flyers soon found, however, that it was possible to go widely out of their reckoning on account of the unknown speed and direction of the craft in relation to the ground; in other words, because of the unknown effect of wind. This is a very simple proposition to state, but as a matter of fact for a long time few people other than practical flyers appeared to understand the serious nature of the difficulty, with the result that efforts have been directed towards the invention of extraordinarily elaborate compasses and course-finders

Photo, Vaughan T. Paul]

MR. GUSTAV HAMEL FLYING AT LAND'S END

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

based upon the erroneous idea that an airman always knows just how much wind-drift to allow for. Compasses have actually been advertised as capable of indicating the amount of drift. Of course, no compass can do this, although it is considered by some authorities not impossible that in the future some instrument may be made for the purpose. Attempts have been made to produce an exceedingly delicate instrument that will measure every acceleration and retardation due to the inertia of the machine, and therefrom indicate the extent and direction of the drift.

One aeroplane compass contains an adjustable pointer attached to the dial. This compass is swung in a transparent container, and whereas the compass card, showing the degrees and points, is relatively small, the pointer is conspicuous. It is necessary for this instrument to be mounted below the pilot so that he can look through it at the ground over which he is flying. The pointer is set to the course desired. This course is drawn on a map. If the course be due west the pointer is turned until it points to due west on the card. If there be no wind it is a simple matter to follow the line, but in a side wind it will be observed that objects below the machine, seen through the transparent container, do not pass in a straight line parallel to the axis of the machine, but across the field of vision in an oblique direction. The use of the pointer is to serve as a guide to estimate the amount of drift. An estimate of the amount of drift having been made, the pointer is set at a certain angle to the axis of the machine. If the correction has been sufficient, objects on the earth below pass by parallel to the pointer. The angle of the pointer to the proper course shows the amount of allowance that must be made for drift. This compass is merely mentioned to illustrate one of the problems of aerial navigation. The average aviator goes to work in a more or less rule-of-thumb way, and finds it quite sufficient for the voyages that are possible with the machines at present in existence.

Briefly stated, the difficulties in the way of accurate aerial navigation are the unfamiliar aspects of well-known objects seen from above, and the still greater difficulty of identifying unfamiliar country from the map, the absolute impossibility of finding the exact locality when the earth is hidden by clouds, or if only an expanse of sea be visible, and the absence of any means by which the exact strength of the wind can be ascertained, even though its direction be known. As to the latter, the airman can tell approximately the direction of the wind if he be in sight of a flag or a smoking chimney, and he can then make a rough estimate of the strength of the wind near the ground, which, however, can be very different from that of the wind at the altitude at which he desires to fly.

It must be remembered that the conditions in any ordinary aeroplane preclude so careful an examination as is possible in any ordinary well-found yacht. It is, nevertheless, possible when flying over recognisable land to perceive the exact divergence to right or left of the course, and the precise delay or assistance due to opposed or following wind ; but in a machine travelling at upwards of sixty miles per hour, a very few minutes out of touch with the map, through mist or any other cause, may be sufficient to confuse the pilot completely. His compass tells him approximately the direction of due north, but it does not inform him of the exact progress of the machine, and once he is out of touch with his map it may be extremely difficult for him to pick up the route again. Every aviator who has done cross-country work has had experience of losing his way. During a journey from Paris to England the aviators[1] went astray forty miles owing to fog, although each had a map and could see the compass.

In the worst circumstances conceivable it might even be possible, without knowing it, to travel in the opposite direction to that for which the head of the machine points. This would happen when travelling over the clouds, or over the sea out of sight of land, in face of a head wind of greater velocity than the speed of the machine. The compass would merely indicate approximately the direction of due north; it would not reveal anything about the progress of the machine; and, meanwhile, a powerful air current might have begun to flow since the traveller left land. No less embarrassing to the air-navigator is the far more frequent unperceived side deflection from his route caused by changes either of the strength or of the direction of the wind occurring after he has left earth, and particularly in fog or when over the sea or over unknown country. He cannot feel a change of wind. The rush of air is always full in the face save for brief moments during side-slips when turning sharply.

Aerial navigation is entirely different from sea navigation for the reason that the craft is totally immersed in the element in which it moves. Its case is, however, similar to that of the submarine, save that the submarine has only to reckon on currents and tides of, at most, five or six knots per hour, whereas aircraft commonly fly in air currents of twenty and thirty miles an hour, and not infrequently in currents up to fifty miles per hour. Further, whereas sea currents are mostly charted and regular, air currents are extremely irregular, are little understood, and are apt to spring up with little warning in great strength from any direction. Probably many aerial currents are as constant in their general position as are sea currents, but varying in power.

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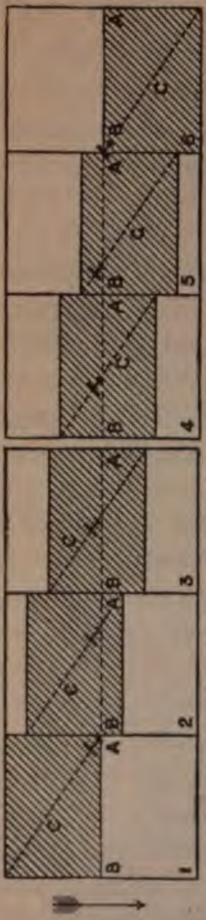
[1] Mr. Gordon Bell (Pilot) and C. C. T.

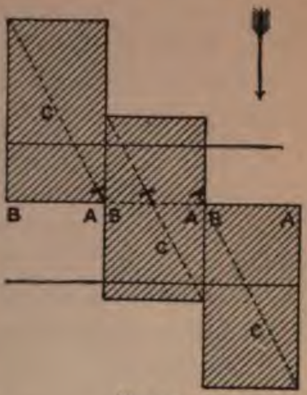


No. 1.—Effect of Wind on Direction of Flight.

If it were not for the uncertainty of the wind the task of finding the way in the air would be easy enough, notwithstanding the difficulty that is often experienced in recognising from above landmarks well known when seen in the more familiar aspect they present to the mere earth-crawler.

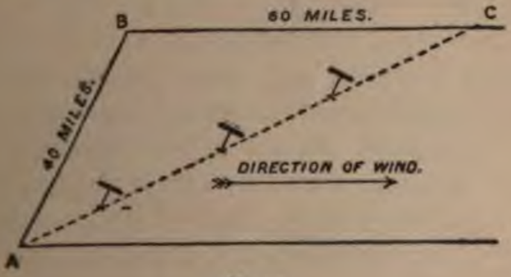
In 1 and 2, A is the starting point and B the destination. The shaded portion represents a body of air, *i.e.* the wind moving in the direction of the arrow. The diagonal line C is the path of the aeroplane in regard to the air, the dotted horizontal line is its path in respect to the earth. No. 2 shows the effect of a stronger wind than No. 1, *i.e.* a longer body of air passes in a given time; the aeroplane, therefore, has further to travel in regard to the air, and takes longer to arrive at B.

No. 3. An aeroplane, at a speed of twenty miles per hour, sets course for B without allowing for the wind, which is blowing at thirty miles per hour from left to right. It is forty miles from A to B, and sixty miles from B to C. In two hours, therefore, the machine instead of arriving at B finds itself at C.



No. 2.

As Col. Renard wrote long ago, 'For the aeronaut, who belongs not to the earth but to the atmosphere, wind does not exist.' Wind must be regarded as a body of air in motion carrying the air-craft along with it. The machine can move about that body of air, and its motion, relatively to the earth below, is the component of its own movement with the movement of the body of air. Again, as Col. Renard says[1] of the dirigible balloon, and it applies equally to the aeroplane, 'The wind changes nothing, either in the nature of the efforts it has to undergo during the voyage or in the speed of its displacement in relation to the aerial ocean in which it floats; and everything goes on as if, the air being perfectly motionless, the earth were flying



No. 3.

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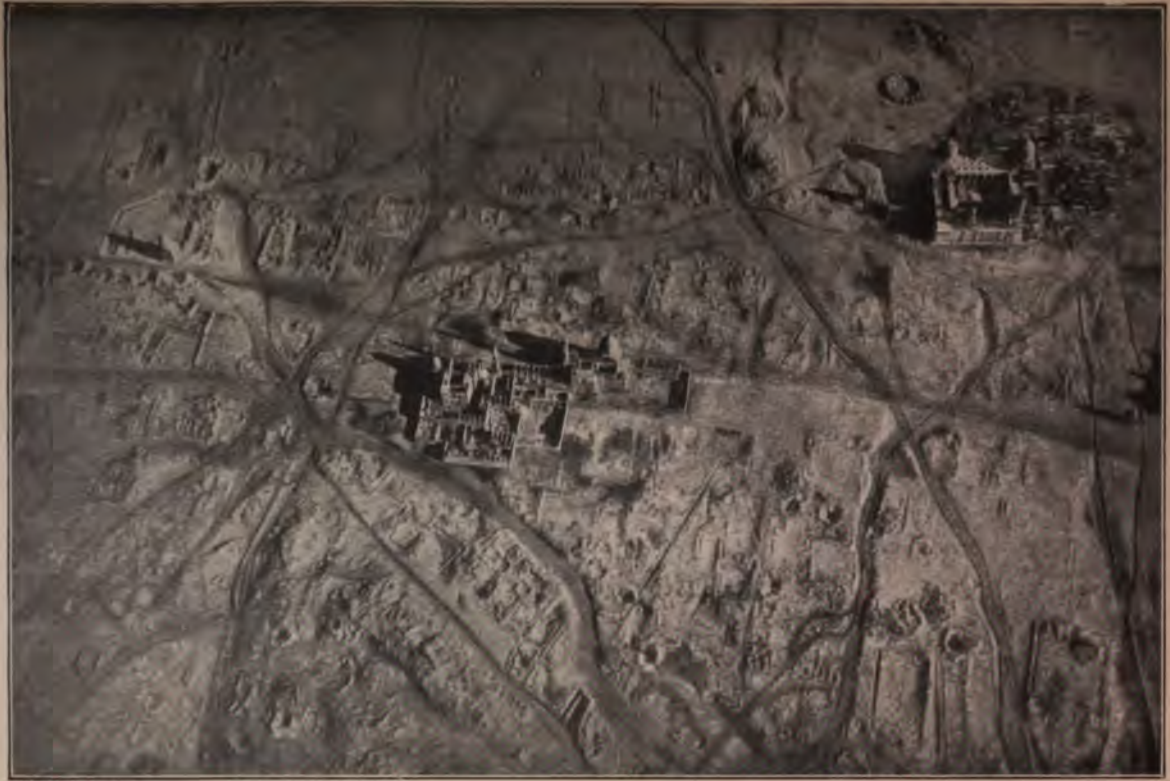
[1] Col. C. Renard, 'La Navigation Aérienne': lecture delivered to the Société des Amis de la Science, April 8, 1886.

beneath it with a speed equal and contrary to that of the wind.'

Yet it is sometimes said that an air-craft can 'tack' to and fro like a marine vessel, to gain a point in an adverse wind!

It is correct to say that the rush of air is always in the face, and that its strength is that of the independent speed of the machine. There are moments, however, when the rush of air varies in strength and direction due to sudden irregularities and gusts, and at times through the machine slipping away to one side when turning. In the case of gusts, the machine does not immediately respond to the difference in the speed of the wind, and for a moment its independent speed in the air is less or more, as the case may be, than in normal flight.

This is a matter upon which a good deal of misconception is found. It is believed by many pilots, and is so earnestly maintained by them that it seems there must be some ground for the claim, that when flying against the wind an aviator feels greater wind-pressure than when he is flying with the wind. Theoretically, this cannot be the case, since every machine, to maintain horizontal flight, must pass through the air at a certain speed to get the correct amount of support. On the other hand, there exists the difficulty, further explained in another chapter, when flying against a gusty wind of keeping the head of the machine down, or, when flying with the wind, of keeping the head up and the altitude maintained. The difference is so slight that a great many pilots and people who have been up as passengers have failed to notice it, yet it seems reasonable enough to suppose that against the wind an aeroplane may be to a very small extent self-



'Motor,' Berlin]

THE MOSQUE OF EL AKRAF AND THE GRAVES OF THE CALIPHS

(Taken from a balloon by Captain Edward Spelterini)

T[illegible]
PU[illegible]

[illegible]

supporting on account of the pulsation of the wind, and everyone knows that birds in soaring flight in many cases avail themselves of a head wind. It has been suggested, by the way, that the onset of a gust is more sudden than the falling off of the wind's velocity at the end of a gust. This might considerably affect the behaviour of a flying machine. Capt. Duchêne writes[1] in one place, 'All machines capable of moving through the air behave in a regular wind in exactly the same way as in a dead calm. The dirigible balloon or aeroplane becomes part of the air which carries it along.' In another chapter he writes: 'These gusts, by the way, are more frequent when the machine is flying into the wind than when with the wind, for the simple reason that the gusts have a certain speed and the aeroplane, therefore, meets more of them in the same space of time when flying into the wind than when travelling with it.' This seems to imply that the aviator flying in gusty weather is in much the same case, though of course in a far less degree, as the pedestrian who, walking beside a tramway, meets more cars in half an hour than those that in the same period overtake him. The difference in the case of flying must be minute, for, as already explained, horizontal flying depends upon the maintenance of a certain speed—the machine's normal speed. Wind is not invariably gusty; at times even a strong wind—more particularly at high altitudes or over the sea—is quite steady. This is a long, but important, digression, necessary in order to make quite clear the difference between air and sea navigation.

The danger of unknown deflections from the course is great, especially to an aviator crossing the sea, even so narrow a sea as the English Channel, which should never be undertaken save in clear weather. The late Mr. Cecil Grace was, in all probability, drifted to an extent which he could not estimate up Channel, with the result that he lost sight of land and his fuel ran out before he was able to reach safety. There is danger even with the land in view all the way, for the simple reason that it is possible to set a course allowing for the wind, and then, by flying into a different current, to go miles out of the way in a few minutes. The path taken across the Channel in that case becomes a zigzag, and in a machine with limited fuel-carrying capacity the danger of an enforced descent on to the water is enormously increased. In a flight early in 1913, on leaving the English side a west wind was met and the course was set accordingly. After flying for a little more than twenty minutes the aviator[1] thought he ought to be somewhere near the French coast, but no land appeared. Presently he sighted a fishing boat, and instead of the machine shooting past, it approached quite slowly. Then the same thing happened with another boat, and the pilot began to realise that, instead of flying between 90 and 100 miles an hour, as he expected, he was actually flying very slowly indeed. The engine was giving its full number of revolutions, and the machine was quite steady, but the fact remained that he was making very little progress. Finally, after an hour, he espied the French coast almost at the spot for which he was making, near Calais, showing that he was on the true course. As soon as he had left the sea and got over the land he came into clear weather, and the machine promptly shot forward at the ninety-miles-an-hour gait at which it had left the English coast. However, as the crossing had taken so long, it was not worth while going very much farther, so he turned round and descended on the Plage at Calais, just at the end of the boat pier, so that all he had to do was to take the wings off the machine, roll her on board, and bring her back by the boat leaving half an hour after his arrival. Now the extraordinary thing is that, with a westerly wind at Dover and a very much stronger westerly wind at Calais, there was an absolutely reverse wind a few miles to seaward of each. This is a common condition in the Channel, and it is one that aviators would be wise to recollect. On another occasion when crossing the Channel in somewhat misty weather, to add to the uncertainty the compass became jammed and useless, although, for reasons already explained, even the best of compasses is only reliable in a very limited degree unless the airman is quite certain of his locality. For an hour the aviator[1] pursued, as he hoped, a steady course, but no doubt in reality wandered about considerably. He was then fortunate enough to sight one of the cross-Channel packets, and was able to pick up the direction from the steamer and from its white wake. Until this friend in need appeared he was in a hopeless quandary, quite unable to tell which was north and which was south, and only certain of the fact that he was on a machine carrying him at a speed of seventy miles an hour in some direction or another, and that in a very short time in the nature of things he would be compelled to come down into the water through exhaustion of petrol.

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[1] *Mechanics of the Aeroplane.*

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[1] G. H.

Before starting on a cross-country journey the strength of the wind must be roughly estimated, since it cannot be accurately determined by any instrument on the ground. Having started on the journey and attained the altitude at which it is intended to fly, the first thing to do is to take a line between two fixed points in the landscape, head the machine accordingly, and then observe to what extent, if any, the machine passes either to the right or the left of the second point. After that it is a comparatively simple matter to correct the compass course on the supposition that the same amount of drift will continue throughout the journey. But the course should be constantly checked and verified, for the wind seldom remains constant in speed and direction for any length of time and the aviator, it must be remembered, is rapidly travelling from one region to another.

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[1] G. H.

For example, if it be desired to fly to a point due northwest, and a line be taken on a point, say six miles ahead, if this spot be passed a mile to the west, the head of the machine must be turned considerably round to the north. After a little experience and knowing the speed of the machine, it will be found in the majority of cases possible to fly very near a true course. In a voyage from Dover to Malines,[1] a distance of 150 miles, after the first correction of the course by this method, no other correction was necessary, the machine going straight to its goal. But in a flight from Dover to Cologne,[2] the air being in an extremely disturbed state throughout, a true course was not kept. Violent storms of rain and hail were encountered, the first in mid-channel; it was a severe hailstorm, and the airman and his passenger had a very bad time.

Land was reached a little to the south of Dunkirk, and, steering by compass, a course was set for Malines. From that point, which was made with precision, Cologne lay due east, but the pilot had to reckon with storms, which forced him to edge away to the northward, giving way, but disputing every inch of ground, as it were, with his persistent adversaries. The result was that when the Rhine was reached, it was at a point some twenty miles north of Düsseldorf and fifty miles north of Cologne. This deviation lengthened the journey considerably.

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[1] By G. H.

[2] Ibid.

The weather not only affected the direction but the altitude of the flight. In order to keep out of the masses of storm clouds that blocked his path the aviator was often obliged to fly very low, much lower than he liked. Sometimes he flew between two storm centres, dry, while the rain pelted down on either side. At Düsseldorf the aeroplane was moving in a wrack of storm-cloud, the rain was falling heavily, and probably nobody in the town noticed the craft, although it was flying at an altitude of no more than 600 feet, but those on board marked every feature of Düsseldorf, including the sheds in which the Zeppelins are housed.

The pilot steered almost entirely by compass. That instrument guided him across the Channel, over Belgium to Malines, and afterwards on the storm-buffeted journey to the Rhine.

In short journeys and in ordinary weather, courses made in this way are perfectly satisfactory; but in prolonged voyages, even in ordinary weather, it will often be found that, as the day waxes or wanes, the strength of the wind varies greatly. Moreover, it is unusual to keep at a constant altitude in a cross-country journey, and the strength and direction of the wind sometimes vary considerably with different altitudes. It is, in short, advisable to take bearings on fixed points fairly frequently.

The unaccompanied pilot of a machine has not only his course to think about, and the work of piloting, which includes such details as giving attention to the engine and the quantity of fuel in hand, but he must always be on the alert to descend in case of engine failure. He must ever keep in view a possible landing-place within the gliding radius of the machine.

In practical air navigation the need has not yet arisen to take astronomical bearings, because the limitations as to length of voyage have made long oversea flights impossible. True, aviators have ventured far out of sight of land, but they have done so only at great risk. But the advent of a fairly efficient aeroplane, capable of alighting on the water and of making long voyages, will call for navigators who are able to take astronomical bearings. This will be done in the usual way, and the method need not be explained in this book beyond saying that, when it becomes necessary to take the sun's elevation while flying at a high altitude, it will be necessary to employ an artificial horizon, for at high altitudes the natural horizon is not seen as a sharp line. For the rest, the ordinary instrument will be used; not by the man who is controlling the machine, of course, but by an assistant.

The best map to use is one reduced from the Ordnance Survey, a useful scale being two miles to the inch. With a little experience the aviator finds this map more suitable to his purpose than the elaborate maps that have been devised, in many cases, by people who have never had to pilot a machine across country. Many of these special maps do not follow the ordinary custom of having the true north at the top of the sheet, but have the destination in view, in whichever direction it may be, at the top, and the starting point at the foot. It will be found that most practical aviators prefer the ordinary map. Attempts to colour maps with a view to the appearance of the ground seen from above have not been fortunate, and have led only to confusion. The map reduced from the Ordnance Survey shows roads, railways, water and woods very clearly, and the aviator soon reads these signs quite easily, knowing that a road from above looks white or light yellow, that a railway is a black line, woods are dark compared with the surrounding country, and that water, whether a winding river or a lake of any shape, makes one of the best landmarks of all. In the case of a long journey it is well to cut a map into strips and wind it on a roller. This can be unwound as the journey proceeds. It is a very good plan to mark equi-distant lines across the course—and also indicate places, such as intersecting railways or roads, likely to be easily identifiable. The distances between the regular lines may be five or ten miles. Knowing the speed of the machine and, therefore, the time it should theoretically take to fly between two of these points, it is easy to calculate the error. A stop-watch can be profitably employed for measuring the exact time between places a short distance apart.

Experience counts for a very great deal. That of most pilots is that railway lines are superior to roads, at any rate in Great Britain, because they are straighter to follow and therefore more easily recognised. On the Continent, on the other hand, the straight national highways with their borders of trees are as easily identified as are railways, and are visible at a greater height. In coming to a small town which it is desired to identify, it will usually be found easy, by comparison with the map, to observe the direction in which the railway lines enter and leave, and their relation to the main roads. The presence of any patches or streams of water is a great help. In this case it will be seen that one is, to a great extent, independent of the compass; the route is simple, being picked up from place to place by following the map.

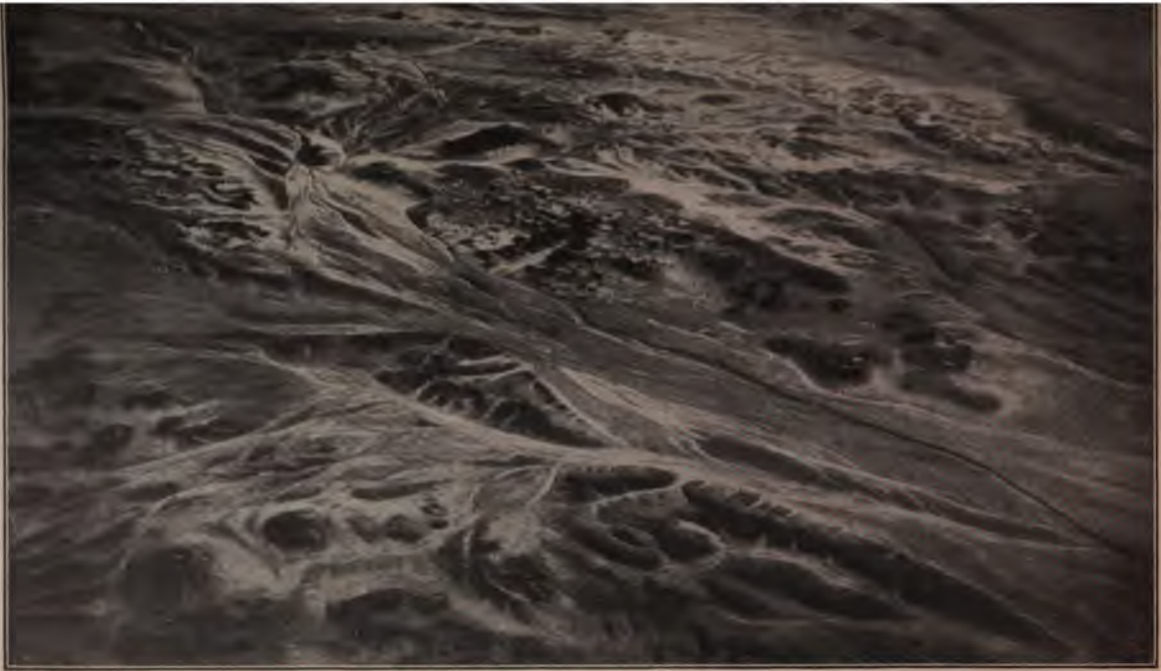
The amount of drift depends upon not only the strength of the wind, but upon its gustiness, and is possibly also to some extent influenced by the design of the machine, some craft more than others having inertia and being more influenced by gusts. Differences of this kind, if they exist, are, however, quite unappreciable, and it may be taken for all practical purposes that a machine drifts to the extent of the wind. That is to say, if it be following a compass course north without reference to landmarks, and a wind of twenty miles per hour be blowing from the west, the machine will, in the course of one hour drift twenty miles towards the east.

To modify the compass course in accordance with a known amount of drift, the following table in Commander R. A. Newton's 'Aeronautical Navigation,' will serve:

CORRECTION FOR DRIFT

For a drift of	Course should be corrected
1 mile in every 58 of one's journey	1 degree
1 ,, ,, 30 ,,	2 ,,
1 ,, ,, 20 ,,	3 ,,
1 ,, ,, 14 ,,	4 ,,
1 ,, ,, 12 ,,	5 ,,
1 ,, ,, 10 ,,	6 ,,
1 ,, ,, 8 ,,	7 ,,
1 ,, ,, 7 ,,	8 ,,
1 ,, ,, 6 ,,	9 ,,
1 ,, ,, 5 ,,	11 ,,
1 ,, ,, 4 ,,	14 ,,
1 ,, ,, 3 ,,	18 ,,
1 ,, ,, 2 ,,	27 ,,
1 ,, ,, 1 ,,	45 ,,

It should be remembered too, that experience is ever growing. After a time the cross-country flyer becomes



'Motor,' Berlin]

THE WIND-SWEPT ARABIAN DESERT
(Taken from a balloon by Capt, Edward Spelterini)

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

very quick in reading landmarks, in interpreting the map, and in estimating the amount of drift; so much so that some flyers, for example Lieut. Conneau who, as 'Beaumont,' won the race round Britain in 1911, are said to possess an 'instinct' for finding the way. Let it at once be stated that 'route instinct' is a valuable possession that can be acquired by every cross-country flyer.

Very curious are the illusions to which the aviator is subject when he once gets out of touch with map and locality. A fairly common illusion, if travelling without a compass when the sun is completely hidden, is that the north has changed places with the south, and the aviator feels almost convinced that his chronometer must be wrong and that it is morning, not evening, or *vice versa*; and that he is flying straight away from his goal instead of towards it!

Provided with map and compass he will, at times, find it easy to make extraordinary errors once he is out of touch with his locality. There are strange resemblances between certain towns and between certain parts of the country. Flying over Towcester, at a great height and not being sure of the route, the pilot,[1] observing his map, became convinced that he was over Daventry. In size and shape the two towns are not unlike each other, and only by flying lower and making careful observation was he able to ascertain his locality. Scores of instances could be quoted of similar uncertainties. Flying over France on one occasion, and having lost the way through fog, two English aviators[2] were misled by the shape of a large wood near Aumale which appeared to resemble that of the forest of Cressy, and continued on an almost westerly course when they ought to have gone north.

[1] G. H.

[2] Mr. Gordon Bell and C. C. T.

With further reference to the map most suitable for aeronauts, the opinion of M. Louis Paulhan may be quoted. He says: 'To find one's bearings in an aeroplane is easy when one is accustomed to cross-country flying. I had never, for instance, made the journey from Orleans to Nogent. I had no railway line to guide me, and I simply followed the direction which I had chosen by leaving the Forest of Fontainebleau at my left and going in a straight line to Montereau. When going at the rate of forty or fifty miles an hour I look more where I am going than to where I am. I take a landmark somewhere on the map which is being unrolled, such as the crossing of a road, a stream, or a town, and I steer straight towards it. It is best, of course, to be at a good height.'

Lieut. Conneau[1] gives the following suggestion: 'Chauffeurs have road maps; why should not aviators have aeronautical ones? They ought to be as nearly as possible the same colour as the soil seen from above, viz., brown. On that brown ground roads might be marked in white, railway lines in black, rivers, lakes, and seas in blue, and forests in green. Signs agreed upon would point out aerodromes and suitable landing places. The principal elevations would be marked in plain figures. Indications of buildings or monuments are not the slightest use to the flying man who looks at them from a height; but it is most important for him to know the particulars of the surroundings of large cities.

'The scale of $\frac{1}{200000}$ths would be the most convenient, for details would be clear enough and the map, even for a considerable flight, would not be too long, its dimensions would be suitable to such speed as has been attained until now. Every possible care should be taken in the drawing of aviation maps, which must of course undergo constant improvements; for, until aerial roads are well known and signals agreed upon, those maps will play a very important part in flights. This is why the aviator prepares his own map so carefully before he starts. He divides his journey into distances of ten or twenty miles according to the machine he is about to use, a slow or a fast one—a thick-coloured pencil line, a plainly-marked figure showing him at once what distance he has flown and what his speed is. He will then know whether he must alight to fill his tanks or proceed on his journey.

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[1] *My Three Big Flights.*

In the early days of aviation neither maps nor compass were used. But it was not long before maps became one of the accessories of an aeroplane and the compass followed soon after, playing as important a part as on board ship. It does not answer as well in the air as on board, for it is too uncertain at a great height, and none have been as yet specially devised for flying machines.[1] It is only in three cases that the compass is really useful. In the first case, assuming that you have lost your way, without consulting your compass you make up your mind to alight; this is of course a mistake, for you may smash your machine in landing, or you may come to ground without anyone expecting you, and you cannot always rely on the accuracy of the information given you by residents. You had much better stick to your aeroplane, look at your compass, and it is a wonder if you do not happen to come across a road, a railway line or a river, all of which should be marked on your map. Proceed according to your compass in a perpendicular direction with the guiding mark. As soon as you reach that mark, follow it, as far as the next road or river junction, or else as far as a turn which it remains for you to identify. You will thus save time.

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[1] This was written in 1911.

'In the second case, suppose that you are caught in the rain, snow, or fog, mere prudence forbids you to alight in such cases, you must therefore again rely on your compass.

'In the third case, viz., when crossing wide expanses of land devoid of any guiding mark, when flying over forests, mountain chains, marshes, or the sea, then you will find that the compass is the only possible guide—and that instrument to which a few aviators object may be your salvation.'

To the aeronaut many of the objects by which the pedestrian and the motorist are guided on their way are invisible, or else unrecognisable. It is difficult to conceive without practical experience the novelty of his outlook. The appearance of the earth itself, for example, gives an opposite effect to that to which we are accustomed. The material evidence plain to all, save those who still believe that the earth is flat, that the earth is a globe is by no means obvious to the aeronaut. Indeed, with a clear view all round, what he can see of the earth, and it is a pretty large piece of it, is slightly saucer-shape, the horizon being on a level with his eye, and the vast plains beneath him deepening towards the centre. This, of course, is pure illusion, and is due to sub-conscious reasoning from the known height of the machine above the ground. The horizon is often veiled in mist. If he had been brought up to believe that human beings live on the inside circumference of a huge globe he would find abundant evidence of that belief, he would have no doubt at all about it.

He is travelling at, say, sixty miles per hour at a height of 3,000 feet, and all the smaller irregularities in the contour of the ground have disappeared. Hills three or four hundred feet in height cannot be perceived, and one village is very like any other village. The village church, the highest and biggest building seen from the land, its spire a conspicuous object from miles around, is hidden. A large village church takes a deal of finding from a height of 3,000 feet. The aeronaut has to argue the matter out from the known plan form of the church, and by looking for the shadow if it be morning or evening. In clear weather usually, however, he will have 'picked up' the village long before getting directly over it, and may have been able to identify the church. The aviator soon begins to look for certain things, and to reject evidence which is not clear. The day, no doubt, will soon come when, for the guidance of aerial navigators, the names of places, or some brief key signs, will be displayed on the ground or on the roofs of public buildings. At an International Congress of Aeronauts, held at Frankfort-on-Maine, it was proposed that all large towns should be made recognisable at sight for aviators by having the names printed in large white letters on the tops of the gasometers. A system of numerical signs was drawn up, each town having a number, that of Dessau, for example, being 75, which figure was painted on the top of the local gasometer. But, unfortunately for this method, the large towns are usually easily recognisable. What the aviator wants is a means of identifying small villages and scantily populated country. Many systems of ground marks are conceivable, and it is probable that they would all be based upon the division of the country into equal spaces, a suitable size being two-mile squares. These squares could be numbered from a point towards the centre of the country, and the twenty-six letters of the alphabet and the nine numerals could be employed in their 234 simple combinations. In addition, each could have E., N., S., or W., for east, or north, or south, or west, or any two of these letters, to show its relative position east, or north, or south, or west of the centre. Each square would have two symbols, except the two lines of squares that interconnected the central point, for each of which one symbol would suffice. These symbols could be marked on the ground either by patches of chalk or by white paint on black ground. Probably, however, it will be found sufficient to have an even simpler method of marks because it is quite possible that in the near future aerial navigation will be so regulated by the authorities that practically the whole of it will be conducted over certain well-defined routes, national and international, and it will, therefore, only be necessary to have identification marks for these routes. It is not likely, therefore, that the beauty of the landscape will have to be sacrificed for the convenience of aerial navigators. On various occasions in cross-country competitions artificial landmarks have been made, usually in the form of white arrows on the ground, but these have not proved satisfactory, the reason being probably that they were too small.

The clearness of vision of the aeronaut is apt to be exaggerated. Too often a thin mist, scarcely noticed by those on the ground, blurs the outline and darkens the land seen from the height of two or three thousand feet. Theoretically, the extent of the view obtainable from an air-craft is enormous. To a man standing on the sea-shore the horizon is three and a quarter miles away, a flag on a mast forty-five feet high and twelve miles distant appears to be on the edge of the horizon. The following table shows the extent of the aeronaut's vision, from which it will be seen that at the height of a mile a circle of country 200 miles in diameter is, theoretically,

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[illegible]
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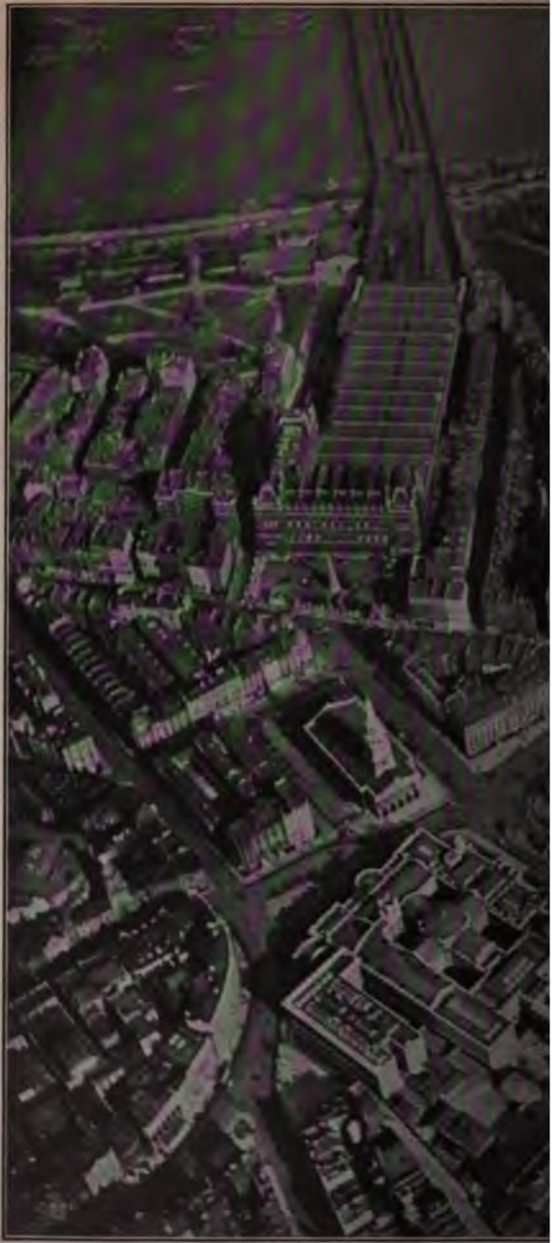

(Taken by Mr. W. J. S. Lockyer, on

'Corona,' at a height of 2,000 feet)

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

in view. Therefore, taking into account the height of the Alps, it should be possible for their highest peaks to be seen by an aviator who ascended 10,000 feet directly over London.

Height in Feet.	Distance of Horizon.
500	30 miles
1,000	42 ,,
2,000	59¼ ,,
3,000	72½ ,,
4,000	83¾ ,,
5,000	93½ ,,
1 mile	96 ,,

In the House of Commons, on one occasion, a Minister said that an airship had only to ascend to quite a moderate height to get a view over 10,000 square miles of sea. This, however, could only be effective vision in very clear weather. According to the weather charts of two different lightships in the North Sea, absolutely clear weather is extremely rare. From observations in 1910 and 1911 the following table was drawn up:

1910	No. of Hazy Days.	No. of Foggy Days.
East Goodwins . .	37	50
Outer Dowsing . .	30	37
1911		
East Goodwins . .	45	61
Outer Dowsing . .	19	36

So that in the neighbourhood of the East Goodwins on one day in every three extensive views would not be obtained.

At times the aeronaut has the good fortune to see magnificent views. In an ascent[1] from Douglas, Isle of Man, in August 1912, on attaining a height of 7,000 feet the aviator could see considerable portions of each division of the United Kingdom. The whole of the coast line from Anglesea in Wales, by Cheshire, Blackpool, and the mountains of Westmorland in England, Wigtown and Kirkcudbright in Scotland, and a big slice of the eastern coast of Ireland, were in view. Immediately below, the Isle of Man formed the centre of the picture. At such a height, of course, all details are lost, so that in the ten thousand square miles or so of the Irish Sea at that time under observation not a ship could be seen. It was a beautifully clear day. In another ascent[1] the airman went to a considerable height just over Eastchurch in Sheppey and had in view practically the whole of the county of Kent, the English Channel, and the French coast from Calais down as far as Abbeville, while on the left hand the coast of Essex and Suffolk could be seen an enormous distance. On November 2, 1913, in an ascent[2] from Hendon with Lady Helen Grosvenor in the passenger's seat, when at a height of 9,000 feet London was invisible through fog, but the whole of the Thames from London to the Medway and westwards from London to Windsor could be seen, while the hills near Guildford and the North Downs to the south and a great extent of country north of London were also in view.

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[1] Flight by G. H.

Finding the way is greatly facilitated when pilot and passenger can communicate with each other, for the passenger has more leisure to examine the maps and observe the country than the pilot. Conversation is difficult while the engine is running, and will not be easy even when the use of silencers, and of engines that can be silenced, becomes general. Speaking tubes have been employed with a certain amount of success. Conversation can be carried on easily for brief periods by the simple process of cutting the engine off for a second or two, and, while the machine is descending, saying quickly what is to be said, then switching on again and levelling out. Another obvious way is to write notes. The occupant of the front seat can write a question or a comment on a slip of paper and hold it up so that the man behind can read it, or the latter can write a note and pass it forward. In ordinary weather the pilot himself is not so preoccupied with the work of controlling the machine that he cannot leave the machine to itself for a second or two while he scribbles a note.

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[1] Flight by G. H.

[2] Ibid.

In this manner Mr. Gordon Bell, piloting a Borel monoplane, wrote quite clearly the words 'This is Meru. How far have we come and in how many minutes?' and passed it forward to his passenger.[1] While he was writing these words the machine began slowly to cant up on the left side, a matter that was easily corrected.

In a flight round Britain on a hydro-aeroplane in an attempt to win a prize of £5,000, Mr. H. G. Hawker and his passenger, Mr. Kauper, conversed by means of written messages. Speaking about his flight, Mr. Hawker said: 'We had duplicate maps of the course, cut up into forty-mile stretches. As we could not hear each other's voices when in full blast we conversed by writing on the backs of the maps. Kauper's charts, stained with sea water, are interesting souvenirs of the flights. I find written on the back of them such remarks and questions as "Hot," "Gunboats," "Where is the bat boat?" (an allusion to an Admiralty machine which should have followed us but did not), "Where is north?" "Back exhaust nut loose," "Nothing to show we are on right course," "No. 3 cylinder joint wrong," "We had better

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[1] C. C. T.

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pull up at Montrose," "We should be there by now," and so on. These short notes bring things back to the mind. I remember Kauper writing his question about whether we were on the right course. It was just after we left Oban. It seemed that we were passing over hundreds of little islands, and the clouds were so low on them that we could not make out the shape of a single one. We had to stick to our compass reading, and luckily it turned out right. A mark on the back of the Scarborough map reminds me that we flew right over Flamborough Head, and only discovered it by recognising Filey Point from the shape on the map. Kauper writes on the back of another chart, "Oil is at 1 lb." That is rather serious. It means that the pressure in the pump has gone down from 9 lb. to 1 lb.—that there is a leak somewhere. We alight, "taxi" along the water, and tie the machine to a rock while we set matters right. Not a man or a sail is in sight. We seem all alone in the world. On the back of another map I find the anxious observation: "We should be there now!" So we should. We had taken a straight cut across the Firth of Forth from St. Abb's Head to Fife Ness. We could see nothing, and we were not feeling too happy. I knew I had steered right by the compass, but had I allowed enough for drift, or were we going out to the North Sea? Luckily we spotted a dim little point of land two minutes afterwards. We both saw it at once. "Is the compass at 285 now?" asks Kauper. It is, and 285 is right. But again the old doubt about the drift. Kauper has no compass. Whenever we get to a ticklish place, and particularly to a control, he draws for me a big enlargement of the map on the other side of the sheet.'

The whole art of cross-country flying can be said to be summed up, after the question of finding the way is settled, in ever having in view a possible landing place, for until machines with dual engines come into vogue, and unpremeditated landings never occur, the aviator will always be face to face with the possibility of having to return at a moment's notice to mother earth. Flying over strange country an altitude of at least 3,000 feet should be observed, but if it be mountainous country this height should be greatly exceeded. It only remains to be said that in Great Britain, more than in France and Germany, it is necessary to keep at a safe altitude and to choose a route with care. In Great Britain the landing facilities are comparatively poor; not only is a large part of the country very populous, but it is thickly wooded and hilly, or else cut up into small fields bordered by hedges and ditches. In some European countries, on the other hand, except in a few regions, a low altitude may be maintained with safety, for a possible landing place within the gliding radius of an aeroplane is always available.

Apart from the question of the nature of the ground below, the state of the weather affects the height at which an aviator should fly. In rough weather it is best to keep at a considerable altitude, because landing, if suddenly it should become necessary, is not so easy a process and requires more consideration, one reason being that if the engine stop during a high wind the aviator has a far greater available alighting area to leeward than on the other side. He must never, of course, for one moment lose consciousness of the direction of the wind.

Using engines which at the best are subject to occasional lapses, the cross-country pilot soon discovers that successful flying is chiefly dependent upon a readiness to make other than the simplest kind of landing.

Versatility in the art of landing is everything, and the occasion should produce the solution. In ordinary weather and with things going well, questions of emergency do not arise, and it must not be assumed that the exciting incidents with which the history of flying is so freely punctuated are the daily lot and portion of the average flyer. He may be flying for weeks without any unusual incident befalling him, but he should always be ready for the occasion when it arises. And above all, he should always remember that even in positions of grave difficulty he may be able to land without damaging his machine. Flying at Workington, in Cumberland, in the spring of 1913, during a south-west gale, a curious landing was effected under considerable difficulty. The flying ground was a cycle track on the north-east side of the town and ascending it would have been necessary, flying head to wind, to pass a short distance over houses. In order to prevent this the start was made with a side wind. The strength of the wind can be estimated from the fact that while over the land the machine, whose independent speed was over seventy miles per hour, could only crawl along at about ten miles per hour. Over the sea it made no headway at all. At a height of 3,000 feet right over the town a descent was begun, and the engine being cut off the machine, of course, was carried away on the wind. Under the circumstances it seemed highly probable that some damage would be done in landing, and in order to avoid that the aviator[1] made for the water, alighting a few yards off the shore where, of course, there was plenty of room and sufficient water to prevent the aeroplane being blown over. The machine was not in the least damaged.

Flying by night has not yet become common, nor

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[1] G. H.

'Flight']

A CLOSE FINISH AT HENDON

'Aeroplane']

EASTCHURCH NAVAL AERODROME
(From an Aeroplane)

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will it be until aircraft are rendered absolutely safe from engine failure, but it is possible to fly at night under certain conditions, and the fact must be recorded that, in the summer of 1913, for some important French and German aeroplane competitions, the usual conditions were altered by extending the hours in which they could be flown to before sunrise and after sunset.

A certain amount of night-flying has taken place at Hendon and Brooklands, flights in good moonlight having been made as long ago as 1910. Where night-flying is done for exhibition purposes guides are put up to facilitate landings. All these arrangements are of a very primitive character, very different from what will be done in the future when travelling by night in the air will be common, and stops will only be made at the appointed and brilliantly illuminated landing stages.

In Germany, where airship navigation is in a comparatively advanced stage, lighthouses for the guidance of the pilot are being established, but aviators everywhere who are called upon to make a landing after dark are conscious of doing so at considerable risk.

There is no great danger in flying by night, provided it be not attempted in windy weather and that the aviator does not fly outside the limits of the aerodrome. It is not at all difficult to get off the ground. The usual run is taken, and the pilot can tell by instinct when sufficient speed has been attained for lifting. He then elevates for ascent and becomes aware by the usual sensations when the machine has left the ground. There is no danger to an experienced pilot of forcing the machine up at too great an angle and becoming 'stalled' —the usual prelude to a smash. He can tell by the behaviour of the motor and the feel of the lever whether he is in a suitable attitude. Once well up he will find that there is a tendency to come lower unintentionally, the reason probably being that he is subconsciously doing his utmost to avoid getting tail down, and is not assisted by a visible horizon upon which to take bearings. It is necessary to have his instruments suitably but not too vividly illuminated. In landing great care is necessary, for almost invariably the distance from the ground is greatly overestimated, so that when the pilot imagines that he has twenty feet clear he probably has not more than five or six feet. To prevent a bad plunge, then, it is best to flatten the machine out the moment the ground becomes visible. Needless to say it is unwise to come down with the engine cut right off —it is well to descend switching on and off ready for emergencies.

Flying from Windsor to London with the 'Aerial Post' in 1911, an aviator[1] was overtaken by night, and he only picked up his direction by the brilliant illuminations of the White City and the Edgware Road. At Hendon, where he was expected, a number of motor-cars had been ranged with their headlights showing on the field; this enabled him to make a landing quite easily.

The question of headlights for the machine is under consideration. The use of electricity involves carrying a small dynamo, and it may at once be said that an apparatus weighing anything less than seventy or eighty pounds would probably be altogether insufficiently illuminative for the purpose.

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[1] G. H.

Rules for Aviation

The following code has been prepared by the Royal Aero Club:

Cross-Country Flying

(*a*) Two aircraft meeting each other end on, and thereby running the risk of a collision, must always steer to the right. They must, in addition to this, pass at a distance of at least 100 metres taken between their nearest adjacent points.

(*b*) Any aircraft overtaking another aircraft is responsible for keeping clear, and must not approach within 100 metres on the right or 300 metres on the left of the overtaken craft, and must not pass directly underneath or over such overtaken aircraft.

The distance shall be taken between the nearest adjacent points of the respective aircraft. In no case must the overtaking aircraft turn in across the bows of the other aircraft after passing it so as to foul it in any way.

(*c*) When any aircraft are approaching one another in cross directions, then the aircraft that sees another aircraft on its right-hand forward quadrant must give way, and the other aircraft must keep on its course at the same level till both are well clear.

EXCEPTION

In the case of dirigibles the distance of 100 metres prescribed above shall be increased to 500 metres.

Flying Grounds

The following special regulations apply only to flying grounds:

(*d*) Two aircraft meeting each other end on, and thereby running the risk of a collision, must always steer to the right. They must, in addition to this, pass at a distance of at least 30 metres taken between their nearest adjacent points.

(*e*) Any aircraft overtaking another aircraft is responsible for keeping clear, and must pass outside the overtaken craft at least a clear 30 metres' distance. In no case must the overtaking aircraft turn in across the bows of the other aircraft after passing it so as to foul it in any way. The distance shall be taken between the nearest adjacent points of the aircraft.

In these regulations the term 'foul' shall include the giving of dangerous backdraught to another aircraft.

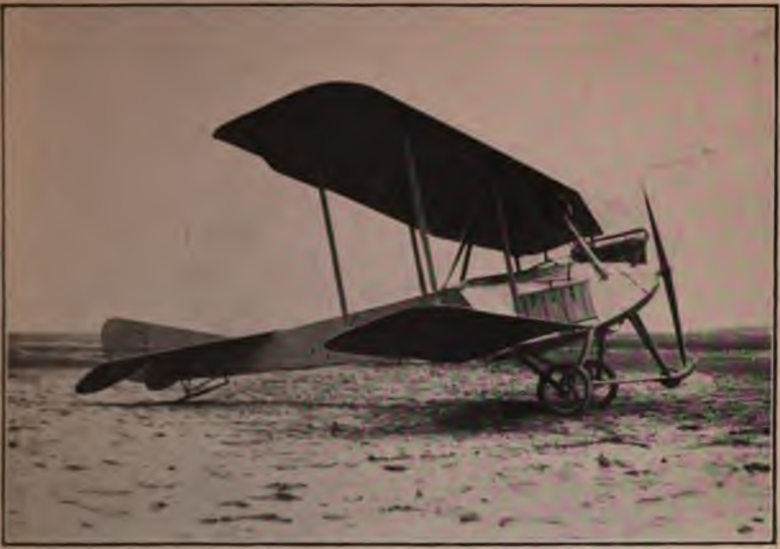
CHAPTER V

CHOOSING A MACHINE

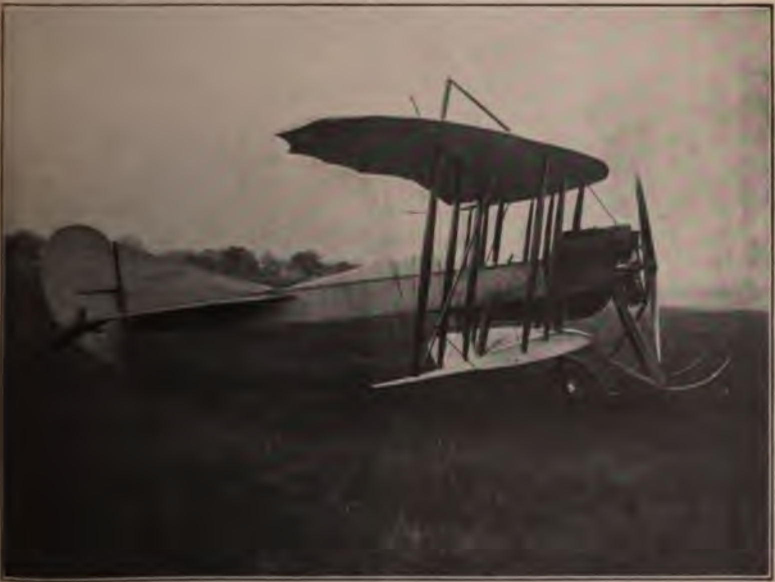
PROBABLY very few aviators make a deliberate choice of a machine after careful consideration of the various types on the market. Far more often they are led by circumstances over which they have only part control. They learn to fly at a school chosen after consideration of locality and the recommendations of friends. Very often their choice of a machine will depend directly upon their selection of a school; they become from that moment an advocate of one particular type. So many pilots are one-machine men; they learn, say, to fly a Blériot monoplane and they remain firm advocates of the Blériot, holding that it is the best for all purposes. Something is to be said in favour of this course, but at least as much is to be said, and will be said in its proper place, on the advantage of knowing how to fly several types. If a pilot enter or belong to the naval or military services, his machine will, to some extent, be determined for him by the needs of the service and by the authorities. But the civilian flyer is his own master, unless he be employed by an aeroplane firm to demonstrate the qualities of a particular machine.

No attempt will be made in this chapter to guide an aviator in the choice of a machine. Indeed, any attempt to do so must fail, for the simple reason that six months after it appeared developments might occur reducing its wisdom to nonsense. All that can be set down is an attempt to guide an aviator as to the considerations he ought to have in mind when making his choice. He should not, for example, be unduly impressed by the making of records. If he require a touring machine, it does not by any means follow that the machine upon which all the world's speed records have just been broken will suit his needs. On the other hand, the making of records does constitute a certain amount of proof that the workshops where the record-breaking machine was turned out are well organised, and that the manufacturers and mechanics are up to their work and mean business.

The principal things to have in mind are the purposes for which the machine is required, and the current opinion among practical flyers, carefully elucidated by inquiry and questioning, as to the qualities of the machines of the day. One of the first questions that the purchaser must decide is whether he will buy a biplane or a monoplane. Two years ago it would have been possible to set down some very sharp differences between the capabilities of these main divisions. The biplane was definitely the slower craft of the two, but it was capable of making comparatively prolonged journeys on one load. It could not fly very fast. The monoplane could fly fast, although not for a very prolonged journey. No such division is now possible; there are biplanes capable of flying at ninety miles per hour; there are monoplanes which at the slowest speed can keep in the air at thirty-six miles per hour. A monoplane has flown with a load of petrol and oil sufficient for thirteen hours' flight. All these instances completely upset the ideas that were generally entertained a couple of years ago. It is, however, reasonable now to demand a machine that will keep aloft at even less than



NATURAL STABILITY BIPLANE, L.V.G. (GERMAN)



"*Flight*"]

NATURAL STABILITY BIPLANE, HANDLEY PAGE (BRITISH)

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thirty-six miles per hour, and it would not be necessary to go into the biplane class to find it. The choice of a machine, then, will depend to a great extent on consideration of such matters as comfort and accommodation, the view obtainable, the transportability and ease with which it can be packed—with questions of climbing and gliding angle affecting the issue to some extent.

Before entering upon these considerations in detail it is perhaps necessary to explain what is meant by the gliding angle. This is the path that the machine will take with its engine stopped. It depends largely upon the weight of a machine and the size, form, and disposition of its planes. The tests of gliding angle, applied in the British War Office Aeroplane Competition, 1912, were made with a view to establishing a standard of a gliding path of one in six. One or two of the machines with a full load were able to descend on a slightly more gradual path even than this. Clearly a good gliding angle indicates a high degree of efficiency.

The question of the view obtainable is important in all machines and—apart from military uses in which, of course, it is vital—in ordinary piloting the pilot should have a clear view of the ground in front of the machine and, as nearly as possible, to a point directly underneath it. In many monoplanes, unfortunately, he is so placed that the wings interfere with his view forward, a circumstance that rather handicaps him in selecting a landing place and in judging the quality of the ground upon which he intends to alight. The biplane undoubtedly gives the designer more opportunity of providing for the comfort and the view of the pilot and passenger, and therein lies one of the reasons for the preference shown by some military authorities for it. In some military types of biplane it will be observed that the passenger or observer is situated in front of the fuselage, which projects well beyond the planes, and, in order that he should have his view uninterrupted, the propeller-behind type of machine is used. The pilot is seated behind him, but not so far behind that his view is greatly interfered with by the lower plane.

If all the pilots of the world were crossexamined as to what they prefer in a flying machine it would be found that very remarkable differences of opinion exist, but it would also be found that many of them had their preferences formed by circumstances. Most 'star' pilots have a preference for a machine very sensitive to its controls. This does not mean a machine that is easily upset or loses its equilibrium in a squall. Pilots like, and feel confidence in, a machine which responds instantly to the slightest movement of the lever. In this preference they would be found in strong opposition to the advocates of the natural-stability machine.

Among the considerations which the purchaser must have in mind is that of power. He will very probably be told that the more powerful the engine the greater will be his safety in high wind and his triumph over the elements. Experience does not altogether bear this out. From careful comparison of the behaviour of a 50 h.p. Blériot monoplane with an 80 h.p. Blériot, it appears that flying in a high wind is quite as safe in the former as in the latter. Needless to say, the low-powered machine cannot make so much headway against an opposing wind, but on the question of keeping balance in strong gusts there is little to choose between the two. Again, the experienced pilot will as readily take up a passenger in a 70 h.p. as in an 80 h.p. machine; there is practically the same steadiness, although the lower-powered craft flies at, say, sixty miles per hour against the other's seventy-two miles

r hour. There arises in this way the vexed question of
e relation of speed to stability, and here it is difficult to
oid contentious matter. Some misconception appears
be entertained owing to the fact that the high-speed
achine rolls and pitches less in gusty weather than the
ower machine; it is believed, therefore, to be safer.
his conclusion overlooks the fact that a relatively small
viation from the level keel in a fast machine may be
ore dangerous than the big rolling movement of a slow
aft. Certainly in flying near the ground and in approach-
g the ground for landing through that part of the air
here usually the most gusty conditions are met, the
lot of the fast machine is called upon to exercise a
ry high degree of skill.

Probably the phenomenon picturesquely called a 'hole
the air' is fully as dangerous to the high-speed machine
to the slow one. For example, let us suppose an
roplane flying against a wind of half its own flying
eed. Now, whether the aeroplane be flying with power,
whether it be gliding downwards with engine stopped,
sudden lull in the opposing wind momentarily with-
aws half of its support. The result is that it falls some
stance, and unless it be at a good height there is great
nger that before it can resume its normal flying or
iding course it may encounter the ground. A good
lot would, of course, not attempt a landing under these
rcumstances, or, if compelled to, would be on the look
t for difficulties. In the case of the high-speed machine,
ith the motor running, and with a slightly downward
th, the rate of fall is accelerated by the speed of the
achine, and the time for recovery by any manipulation
the pilot is correspondingly brief. The very high-
eed machine has, so far as most present designs go, but
all lifting efficiency. With the engine cut off it must

take a steep downward path, and, clearly, the steeper the path the more imminent is the risk of wrecking under any condition of the air by which the normal support given to the planes is momentarily and partially withdrawn. The same danger exists in this and numerous other uneven conditions of the air for all machines, but it is more critical for high-speed machines than for slow ones which, normally, possess a more efficient lift.

Evidence that high speed is no protection against the dangers of uneven air is afforded by the fact that flying at the unprecedented speed of 126 miles per hour in the Gordon-Bennett in 1913, an aviator, M. Prévost, was distressed by the labour of keeping his machine —a racer of very low lifting efficiency—steady through the heat eddies that were very troublesome on that day. He confessed that his work would have been lighter had he been flying an ordinary monoplane of the same type.

It may be admitted that the high-speed machine will generally force its way through small irregularities without taking much notice of them, while in the same irregularities a slow machine will pitch and roll. This does not necessarily mean that the latter is in danger. Certainly when flying low the pilot of the high-speed machine may, by a very trifling deviation, be put into a position of danger; he will require to exercise more skill and quickness than the pilot of the slow flyer. The fast machine of to-day necessarily flies at a flat angle, so that it will take a very small change in the air to transfer the pressure from the under-surface of the wings to the upper, with embarrassing results. For many reasons, then, it is particularly advisable to keep at a high level when flying a fast machine. This, again, shows that the fast machine requires a good pilot; and perhaps it means little more than that in actual practice.

All these considerations apply also to the use of stabilising devices, which are of comparatively little value to machines flying near the ground. Assuming that the perfectly stable aeroplane will be attained, there are very severe limitations to its value. It is, be it said, an eminently desirable machine, but its usefulness will depend very much upon recognition of its limitations. Automatically stable and naturally stable machines encountering a gust, a lull, or an eddy within 100 feet of the ground, will often find their stability a useless quality. Like other machines, they must fall when their support is partially withdrawn, until they recover their way again; and flying at 100 feet or less the chances are that they will come to the ground before recovering support. And if tilted up by a side gust they must necessarily lose altitude before regaining an even keel. High speed and stability are both desirable, but unless it is recognised that neither of them overcomes the danger that lurks at the lower altitudes they will be of little service. Yet the advocates of each are apt to claim that it will make aviation safe.

Capt. Bellenger, a French Army pilot, says[1] that all automatic devices hitherto made are fallible, inasmuch as the manœuvre necessary to re-establish the equilibrium of an aeroplane does not depend directly upon the disturbance itself, but on the cause of that disturbance. Thus two identical positions assumed by a machine, but due to different causes, require different manœuvres. An automatic device can never detect the difference between these causes.

Natural and inherent stability make the work of piloting easier and reduce the possibility of error in piloting. These considerations, clearly, are greatly in their favour. But, like all other pilots, the pilot of the natural-stability aeroplane must observe the rules as to flying it sufficiently high to be sure of a safe grounding in case of sudden necessity. He must be able to select a good landing place, and he must not land with a strong wind abeam. If to natural stability could be added the qualities of a good gliding angle, clear view, big fuel-carrying capacity, and easy demountability, it would be almost all that could be desired. But in a bad smash, due to any error of judgment on the part of the pilot, the inherently stable machine has no advantage over other types, and as to its wind-flying capacity, the good pilot will more readily ascend in a gale in a well-designed aeroplane of the ordinary type than in the 'safety machine.' This preference may, however, in course of time be removed; it undoubtedly exists at the time of the writing of this book.

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[1] *Bulletin de l'Association Générale Aéronautique.*

It is hardly necessary to point out that the variable-speed machine, with variable plane area, and at the same time a high degree of natural stability, or with a really efficient mechanical stabiliser, is an ideal worth pursuing. The slowest machine—or rather the machine capable of the slowest flight in the first place, and with the greatest variation of speed beyond that—will be best protected against the fall experienced in what is known as a 'hole in the air.'

The fact is, the development of the really efficient aeroplane, in other words the machine with the capacity to transport the biggest load in the shortest time on the smallest expenditure of power, has been hindered by the unavoidable setting up of wrong ideals. Speed for its own sake has been cultivated and encouraged by big prizes and by popular demand as conveyed through the Press. Whether in matters like this the popular Press

ETRICH MONOPLANE

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is a true interpreter of the public mind is a debatable point. It is probable that, given a more intelligent lead by their newspapers in the early days of flying, the public might have demanded something very different in the way of competitions and spectacles provided by the first aviation meetings. For a machine that has the quality of high speed only must be relatively inefficient. In flying the power is required not merely to propel the machine through the air but to enable it to rise. A machine in horizontal flight is being constantly lifted up by the power of its engine against the attraction of gravity. The power operates by keeping up flight at a certain speed. Increase of that power causes the aeroplane to climb. Reduction of the power, by diminishing the number of propeller revolutions, causes loss of altitude. In the racing machine the wings are relatively short in span from left to right to their depth fore and aft, and are small for the load they have to carry. Whereas it is usual to design aeroplanes with a proportion of load to wing area that gives at the most 7 lb. per square foot, the racing machine carries as much as 13 or 14 lb. per square foot. This heavy loading is an unsatisfactory feature, and it is quite possible that designers have not made due allowance for it in strength of construction. The racing craft is essentially a one-speed machine, and it must be driven at great velocity in order to maintain flight at all; with the slightest failing of the engine it must return to earth, its descent path being steep and swift. Unless a large flat space is available for it to land in only good fortune will avert disaster. Such a machine must run a long distance after touching ground. This was seen in the Gordon-Bennett race of 1913. In landing his Deperdussin monoplane M. Prévost did not attempt a long glide. He did not cut off his engine until he was quite close to the ground. The speed of the machine then carried it forward a quarter of a mile before its wheels touched earth. The moment they touched it bounded up again, and before it had finally stopped it had travelled 500 or 600 yards.

How wasteful of power is the racing machine is proved by the fact that 100 per cent. increase of power means the addition of a very few miles per hour speed. Thus, a Deperdussin monoplane, driven by a 160 h.p. engine, attained a speed of 110 miles per hour. A machine of the same pattern, driven by a 100 h.p. motor, flew at 108 miles per hour. The heavily-powered machine weighed about 1200 lb., the lighter about 1000 lb. The extra 60 h.p. of the one was therefore required to lift into the air the extra 200 lb. of weight, and the gain in speed was only about two miles per hour.

No attempt can be made to determine for others the choice of a machine, but it may be possible to indicate the nature of the considerations that enter the mind of an old hand when he is selecting a machine. Clearly these considerations vary from year to year, for aeroplane construction is always undergoing changes; new types arise and old types become obsolete. In one type of monoplane the engine in front is almost completely closed in. In another type the engine rotates in a position fairly clear of the main structure of the fuselage. The reason why the engine is closed in in the one case is that only in this way can a certain form of undercarriage be employed, and this landing chassis is probably the finest in the world, for it enables the machine to land in a very small space. At the moment of writing the Blériot type of landing chassis is the most suitable for general cross-country work, for it is possible to bring the machine down into a small field, landing with the wings acting as an air brake, far more effectively than in any other type, in the manner described in Chapter X. In this case the tail skid helps to arrest forward movement after touching the ground. Another general type of machine, in which this kind of landing carriage is not employed, obtains an advantage in another direction, namely, that the engine is not closed in. The advantage is ease in overhauling the engine, and this is extremely important. What it means in practice is a difference of over an hour in getting the engine out, and the same period in getting the engine back again, or about two hours of a mechanic's labour, representing not only expense but valuable time. Yet another drawback of the closed-in engine is that in the case of a cylinder breaking out in the air it is extremely likely to tear the whole machine to pieces, whereas, in the other type, the cylinder may break and there is a very good chance of loose fragments flying clear without wrecking the machine.

Another consideration in choosing a machine is the relative position of pilot and passenger. For reasons of design, to which reference need not be made here, it is often found that the 'tandem' position, one behind the other, has an advantage over the 'sociable,'—better balance thereby being assured. But a great deal depends upon the distance between pilot and passenger. Where they are close together the flight attitude of the machine is comparatively little affected by differences in weight which, of course, are most felt in the case of an engine running badly. For example, in the case of a machine in which the passenger is situated two or three feet behind the pilot, if he be a heavy man and engine trouble be experienced, the machine will fly in a tail-down position. In machines in which the pilot and passenger are close together there is far less trouble from this cause. And the disability has to some extent been overcome in certain types of biplane having sloped back wings in which pilot and passenger are seated wide apart and the stability is not adversely affected. Where the passenger sits behind the pilot it is an advantage, for observation purposes, to be nearly clear of the trailing edge of the wing. In addition there are questions of the relative advantages of having passenger or pilot in front.

On the whole, it is good policy to be suspicious of new ideas in flying machines and all new and untried combinations, say, of good propellers and established designs. A machine may behave extremely well with one propeller and give very unsatisfactory results with another. In the early days it was common to find unsuitable combinations offered; but of course, with increasing and more precise knowledge of the subject, there is less excuse for error and blundering. Yet for some years to come, no doubt, a great deal of aeronautical work will have to be carried on more or less by flying experiments; it has been well said that the aeronautical laboratory is the air itself, and no longer indoors. Every Aeronautical Exhibition is productive of more or less fantastic devices which have caused their contrivers enormous labour, avoidable by consultation with experienced men. Always with us is the designer who seeks to be original rather than sound. Aviation being a new thing it is highly productive of freak devices. It is impossible to go to an Aero Show without finding examples. It may be a new shock-absorber weighing perhaps 40 lb., although there are well-tried and satisfactory shock-absorbers in use weighing less than 5 lb.

Reference has already been made to inherently and automatically stable machines—the distinction being that the former is stable by reason of the shape and disposition of the wings. The automatic stabiliser, on the other hand, is a contrivance attached to the machine. One fault of all of these is that unless they can also be hand-controlled in the event of anything going wrong with the stabilising mechanism the pilot is in a far worse case than he would be on an ordinary machine. The inherently stable machine, then, which depends on no delicate mechanism, on this account appears to have the advantage. But stabilisers, no matter on what principles they are based, do not render the machine immune from extreme upsetting influences. And in some cases, far from being stabilising devices, they are rather the reverse, this especially being true in the case of some that are based upon the pendulum principle, through the very nature of the pendulum itself. The whole question of stability devices was fully gone into in a paper read before the Aeronautical Society on January 29, 1913.[1]

Reference has already been made to the desirability of evolving an efficient machine with a big range of speed. Many machines having a speed-range are on the market, and on some extravagant praise has been bestowed by high authorities. It will be well then to point out one precaution that must be taken by those who may be inclined to favour this type. Designers of machines with a big range of speed have great difficulties to contend against, no matter how efficiently the engine employed may work at the extremities of low and high speed. On the top speed a machine is necessarily driven at a flat angle and therefore with the centre of pressure very far forward. On the high speed, then, there is a very small margin of stability, and with a little provocation the pressure may be transferred from the lower to the top surface of the planes. No speed-range machine whose top speed is only obtained by flying at a very flat angle, can be regarded as a success, since it possesses one of the faults of the merely racing craft, and that, moreover, in an aggravated form, with the additional offence that it has by some been extolled as a necessarily safe machine. Until aeroplanes are furnished with wings whose angles or area can be varied during flight in relation to changes of engine power, probably no thoroughly satisfactory speed-range machine will be possible. This, however, concerns the future of flying. Some advance in the direction of the speed-range machine has possibly been made by the employment of a new wing-section, the result of the work of M. Eiffel. This wing-section has a double top camber. It appears like two narrow wings placed one behind the other, the leading edge of the rear one joined to the trailing edge of the one in front. In passing through the air this type of wing has two regions of reduced air pressure on top, one behind the other. In the ordinary wing there is only one region of reduced air-pressure, immediately behind the top of the curve. An advantage of the new wing-section, therefore, is that the centre of pressure can move over a larger range. Increased lifting power is claimed for it.

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[1] *Aeronautical Journal*, April 1913.

The choice of a motor presents many problems. Perhaps the best advice to give is to use that motor which is most in favour with experienced men at the moment. One or two general questions may, however, be considered here, to be taken in conjunction with facts relative to the cost of fuel for different types in the chapter on Aerial Touring. The principal question is that of the advantages and disadvantages of the rotary type of engine.

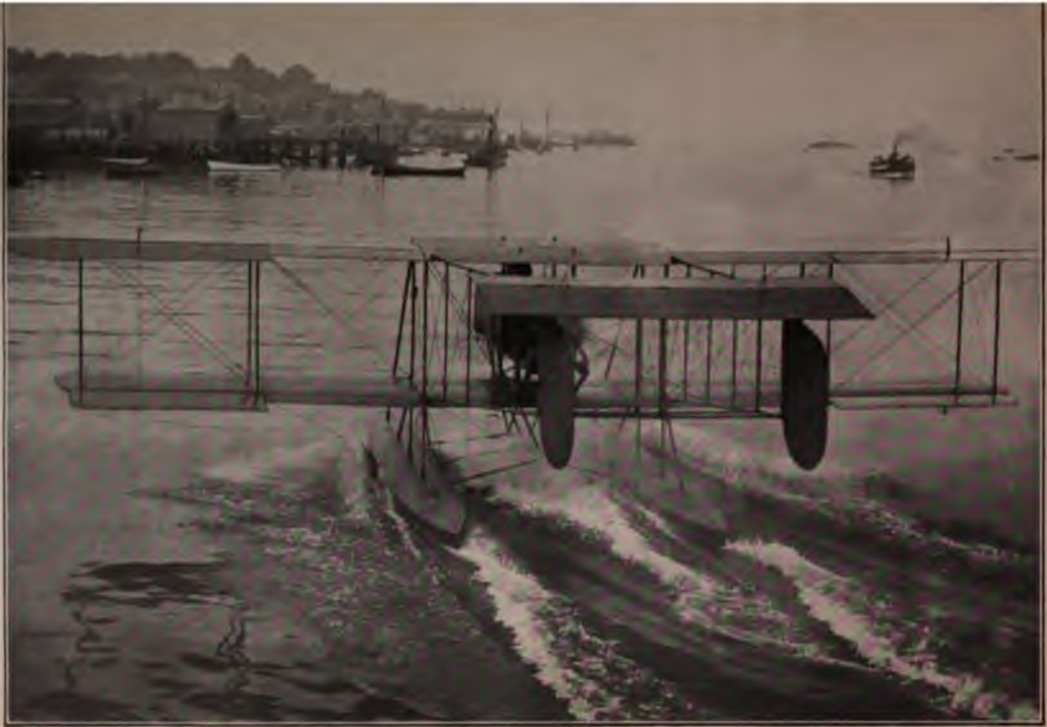

Photo : Debenham, Cowes]

'WIGHT' SEAPLANE STARTING A FLIGHT

It was the Gnome motor that made possible the very swift progress in the art of flying between 1909 and 1913. In spite of its many disadvantages there is, however, a general recognition of the fact that if certain drawbacks can be overcome, the stationary engine will be preferable. The rotary type gains by lightness due to the fact that it is air-cooled and can dispense with radiators and water tanks, and that it must of necessity have light cylinder castings. Owing to the rotary arrangement of the cylinders the crank shaft must be very short, and therefore a further saving of weight is effected. Further, no fly-wheel is necessary. Evenness of running is another advantage, due to the fact that the cylinders themselves turn round the fixed crank shaft, and the result is that there is very little waste of power due to propeller 'flutter.' There is very little vibration with the rotary type of engine. As to the alleged gyroscopic effect of the rotary type, this is so small as to be negligible.

The disadvantage of the rotary engine is the air-resistance offered by the cylinders, which must use up a considerable amount of the horse-power of the engine. This is, to some extent, obviated by the use of stream-lined casing for the engine. The force to turn a rotary engine at the high speed demanded is considerable, and this also represents waste of power. Finally, the rotary type uses up an inordinate quantity of lubricating oil, and is also expensive in the matter of fuel. Part of the advantage of the light rotary motor is lost through the need to carry larger supplies of petrol and oil, and because the lubricating oil must be the best castor oil, which is not readily obtainable everywhere. Another disadvantage of the rotary type of engine is that it cannot easily carry an efficient silencer, for the reason that the cylinders themselves revolve. This is a drawback that must count against it in the long run. Again, no air-cooled engines of the rotary or of the radial type are suitable for use in seaplanes, owing to the warping effect of a cold wave striking a heated cylinder after alighting.

The choice of a propeller is really best left to the maker of the machine, since it involves many intricate problems. At present, propeller design is very much in its infancy, and no hard-and-fast rules can be laid down. Many developments are certain to take place. It may be interesting to make one remark, based on practical experience of different types of propellers. It has been said that propeller 'flutter' is largely prevented by the rotary type of engine, and that is true. At the same time, in turning a machine sharply in flight, even with a rotary engine, propeller 'flutter' is caused. This is experienced either in turning to the right or the left.

CHAPTER VI

SOME PRACTICAL POINTS

So many accidents have been attributed to 'something amiss with the steering apparatus' or some other part of the aeroplane that it seems as if aviators must be extraordinarily careless of their machines, and that they hazard their lives in the most unthinking way. It was probable that the desire for lightness of construction and the avoidance of all unnecessary obstruction to the air were responsible for the fragility of some of the early flying machines. And the rate of depreciation is rapid. A damp atmosphere soon leaves its traces on the fine metal work and the fabric employed. A very little rust must be sufficient to weaken critical parts of the structure. Many aviators do not pay sufficient regard to this danger. There ought to be frequent and exhaustive overhauling of the machine. It is evidently not sufficient merely to see that the controls are acting properly. Every part of the machine should be examined and, at the slightest sign of wear, replaced, for, far more than any other vehicle to which man trusts his life, the aeroplane is dependent for security from grave disaster upon the perfection of every part of it. The risks that aviators have taken with their eyes open are almost beyond belief. Fernandez tied up a broken rudder with string rather than wait to have it properly repaired with wire. He paid the penalty with his life. Lefebvre trusted himself on a machine which had not been properly overhauled. He also paid the penalty. One is amazed at the risks aviators have taken rather than disappoint a waiting crowd.

Aeroplanes are rapidly being improved in the materials employed in their construction and the means available for keeping them in order. An aeroplane will last for two or three years in constant use, unless it is very often transported by the railway, when it suffers a certain amount of deterioration if not carefully covered and carried. At the end of a year the fabric, unless it is perfectly 'doped,' should be taken off the wings and renewed. This is an advisable precaution, although it may not always be strictly necessary. The fabric is sometimes knocked about a good deal through the processes of taking down and re-erecting the wings; and in many cases, the unwelcome attentions of the crowd, and of people who scribble names on the wings, are deteriorating influences. The oil thrown back from the engine does not in the least injure the fabric, it may be easily wiped off provided the fabric has been properly 'doped.' The fabric must not be allowed to get slack, as it will tend to do under hard usage in different temperatures and in wet weather. But, properly treated and with reasonable care, it will need renewal not more than once in three years. The wings should be watched from time to time to see that the tips, which are in frequent movement by the warping control, do not become weak, and in some machines they are apt to get a permanent warp upwards which interferes with the ease of control.

A great deal of nonsense has been written concerning the endurance of an aeroplane motor. Even the delicate rotary type of motor will last for many years working at high efficiency with proper care. Proper care of this motor involves a renewal of the piston-rings after every twenty or thirty hours of actual flight. If the flying time consists of short flights the total may be as much as thirty or thirty-five hours, or a distance of about 1500 miles, before renewal is necessary. The motor has to be taken down for this operation and the new rings put in, a set of seven costing £2 9s. The operation takes a day, but the need for it is an excellent fault, because it ensures that the engine is then thoroughly overhauled.

The aerial tourist should carry with him two or three spare plugs, a complete spare inlet valve, an exhaust valve (valve only), two fixed spanners for the inlet valve, a screwdriver, a screw spanner, and pliers, all of which are made up in a small leather case weighing about 10 lb. He should carry a spare oil bulb, this being made of glass and therefore apt to break in varying temperatures. He requires a petrol squirt for injecting petrol into the engine preparatory to a start after a long halt, and a spare carbon. It is advisable also to carry a few feet of spare wire and some U pieces to repair breakages in the fuselage and chassis. The aerial tourist cannot always expect such amazing good fortune as befell an aviator[1] who, having flown some 150 miles from Dover was forced to land near Malines through the breaking of an inlet valve spring, and actually came down in a field where two mechanics who, unknown to him, had been deputed by the makers of his machine to be in attendance *en route*, happened at that moment to be. They had no reason to suppose that he would land at that point, and indeed they were not looking for him.

A pressure gauge is required when a spare tank is carried behind the pilot with a supply of fuel for a long journey. As the front tank empties it is necessary to fill it up from the other, and for this purpose a pressure pump is employed. In long distance flying a very good rule is to keep the tank in front well filled. In some machines, instead of the pressure pump, power is derived from a tiny propeller placed below the fuselage. The rush of air keeps this propeller whirling. It is, in fact, a wind pump.

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[1] G. H.

Certain rules should be followed by the aviator who desires to take the best possible care of his motor. These may be summarised in the following way. The main consideration with the rotary motors, now so much employed, is to use as small an amount of petrol as possible for the power desired. Supposing the motor will turn at 1,150 revolutions per minute, and the machine will maintain horizontal flight at 1,050 revolutions, the pilot should see that the latter number is maintained. The way to proceed is as follows. Get the engine running as hard as it will for a start. Watch the revolution counter. Then manipulate the air-regulator, when possibly it will be found that more revolutions can be obtained with the extra air lever less open, or fewer revolutions with it fully opened. This may depend largely on the condition of the atmosphere. Having attained the greatest number of revolutions the petrol supply should be cut down as low as possible while maintaining horizontal flight. Flight is then being maintained with the lowest possible fuel consumption, which is advantageous by better preserving the cleanness of the cylinders, by keeping the motor from heating, and increasing the distance of flight possible on one load of fuel. When it is desired to climb to higher altitudes, an increased fuel supply will be necessary. Excessive petrol consumption means that, after a very short flight, the engine gets hot, and then

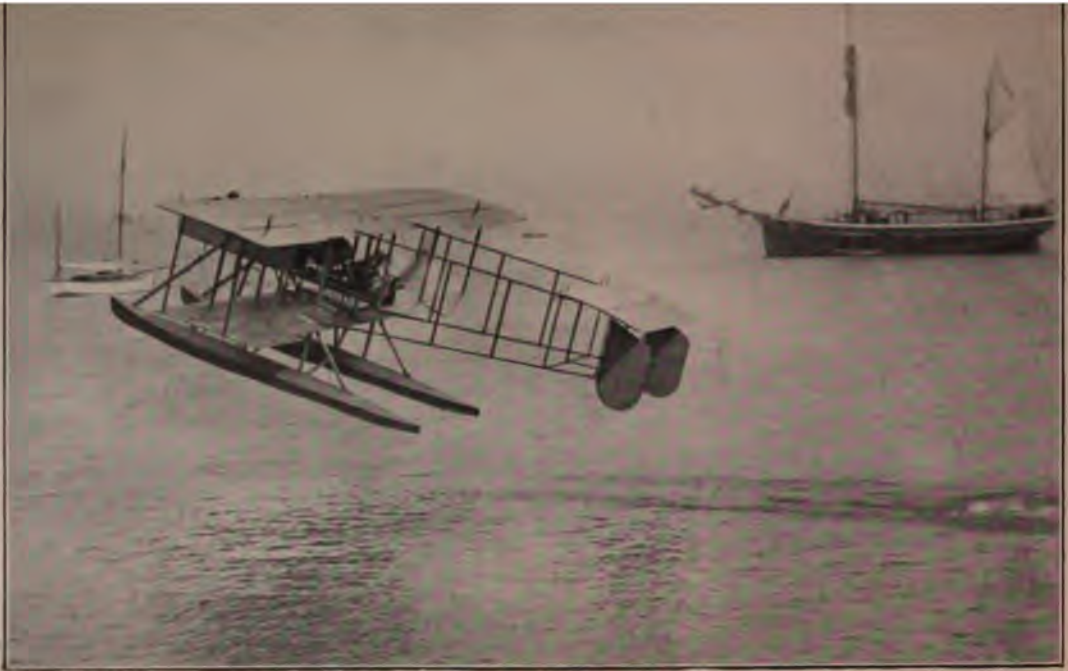

Photo: Debenham, Cowes]

'WIGHT' SEAPLANE GETTING OFF THE WATER

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when a landing is made and it is switched off some of the cylinders will continue to fire, just as the engine of a car, at the top of a long hill, running fast on second speed, will continue to fire and then back-fire after being switched off. A properly cooled engine stops instantly on the switch. After a long flight, with an extravagant consumption of petrol, there is risk of an inlet valve spring breaking on account of the excessive heat. These points relate chiefly to the rotary type of engine. It is not considered necessary here to go over the whole ground of motor care, since any handbook on the petrol motor will give this sort of information.

Much that was said in the chapter on Accidents and their Prevention concerns the care of the machine before and during flight. The reader's attention is directed to the references to the motor in that chapter.

Necessary instruments to carry on flight are a compass, an aneroid barometer to show the height, a revolution counter to show the speed of the engine (this is always in the equipment), a map holder, and an inclinometer. Air-speed indicators are often carried, but they are not very reliable instruments. As already explained, a rough and ready inclinometer exists in the petrol tube or in the compass, when the latter is kept horizontal by means of suspension. A reliable air speed indicator would show whether a machine is getting stalled or is taking on an excessively steep dive. Pieces of string tied to different parts of the machine may serve to indicate to the pilot the direction of the flow of air, and these are often employed in experimental flying. If the machine is not banked enough in turning it naturally slips out either to left or right and the string hangs correspondingly. If over-banked and beginning to side-slip the string, of course, is a tell-tale, although the pilot would have other evidences. In the slip-stream of a tractor machine the string swings permanently to one side owing to the rotation of the air coming off the screw, but this can be allowed for. In a turn of large radius with a slight bank the string may show the machine to be slipping inwards, though from the ground it appears to be slipping outwards, whereas in a steeply banked turn it often shows the machine to be slipping outwards and upwards.

CHAPTER VII

AERIAL TOURING AND THE COST OF FLYING

To everyone who has done much flying across country must come the memories of scenes that make it difficult for him to understand why the lure of the air is not felt by all the world. Over Versailles at sunrise, the great wooded slopes, the winding Seine, Paris in a blur of mist, its only visible feature the Eiffel Tower silhouetted against the red disc of the sun, make an impression never to be removed: ahead and far below, like a black limpet among tangled weeds, Mont Valérien, a landmark for the aerial tourist.

Or, the same evening, crossing the Channel: behind, a great extent of the French coast, but in front of the machine a big slice of the south-east of England visible—certainly the whole of Kent and the Thames Estuary far past the mouth of the Medway; London itself only hidden by mist; the Essex coast a dim outline, and the south coast as far as Hastings, perhaps Brighton; the land appearing as the softest of grey smudges, the sea gleaming pale gold under the sun.

Ten thousand feet over Hendon and the whole of the river from Hampton to the Nore in view. On another occasion, fifteen thousand feet over London, and the coast line from Yarmouth to Brighton dimly visible.

Or, seen from a balloon—which gives the same prospect

—London by night, the lights of its 150 square miles displayed below with infinite degrees of colour, brilliance, and pattern, and overhead the stars, as if one were poised in the interior of a vast illuminated globe, its dark sides frosted with silver and gold, the roof glittering with lights.

Berlin at night, also from a balloon—at a distance a mere patch of milky haze on the horizon. The patch of light with diminishing distance opening out until it stretches from north to south. The leagues of lamps at Potsdam and Charlottenburg and a vast extent of illumination beyond. Berlin seems endless, new features open out every minute. New and unexpected vistas of long avenues of light losing themselves in the blaze at the heart of the city. Slowly the long eastward extension of the city unfolds itself and farther on great expanses of water and forest dimly appear.

Dawn among the clouds which, at the bidding of the sun, begin to bestir themselves with a series of wonderful groupings. Across the north-east a straight row of weird and fantastic shapes appear, black as ink against the lightening sky. They resemble gigantic trees rearing themselves from a flat land covered with white mist. These grotesque shapes appear to be the same clouds that, half an hour before, passed slowly below the travellers in the air—then appearing indefinite and fleecy. The dawn approaches, and a red tinge shows behind the row of cloud trees, which become blacker and more sharply defined. A beautiful green hue is seen above the red. To the south the clouds are bluish-grey. The stars are still very brilliant. Almost suddenly, at about six o'clock, the row of strange trees lifts up to a higher level. Imperceptibly the tree-clouds disappear, and a series of mysterious and ever-changing clouds take their place. One slate-grey, ponderous-looking mass occupies a giant's share of the northern sky: slightly below but with its topmost peaks and domes far above. It is impossible to give any idea of the immensity and variety of these changing scenes. Nothing like them could be seen from the ground. In the south a limitless stretch of cloud-peaks looks like a Switzerland moulded in snow. The impression of distance is wonderful, and probably the view extends to one hundred and fifty miles or more of cloud.

Touring by air is a very different matter in England from what it is in France. The way can be found much more readily in France, where the long straight roads usually bordered by trees, often with main lines of railways running parallel, greatly assist the cross-country flyer. In England, on the other hand, the roads are usually winding, as are many of the railways, and the country is broken up into a confused medley of small fields bordered by high hedges and interspersed with coppices in a way that is most embarrassing from the aviation point of view. Often in England the aviator is forced to land in a very small field. When anything like a breeze is blowing, therefore, he is called upon to exercise judgment and skill that are less frequently demanded of the man who flies over the flat parts of France. The wind, again, in England, is a very much more serious factor than it is in France or in Germany. In the long run these circumstances must result in making the British pilot, taking him all round, superior to the pilots of countries in which training is a less arduous process.

The English aviator has to contend also with the difficulties of a more misty atmosphere and, over the industrial districts, with thickly smoke-laden air.

The necessities of the case early compelled a certain amount of flying in fog at a time when French aviators would have been appalled at the prospect. The result may be that, in this country, the use of instruments of precision enabling cross-country flying to be carried on with comparative safety will become general earlier than abroad. There is some truth in the suggestion that, just as the seas have protected England in the past, when her defenders have had the storm for their ally, so the greater hardihood of her flying men and the comparative severity of her climate will help her against a foreign foe.

The aerial tourist soon observes peculiarities of local conditions which should be observed and noted. Over a great city like London there is, even during high wind, a certain amount of haze. The haze is thickest to leeward, and it is always worst when leeward happens to be the east of London. The reason probably is that the eastern half of London being responsible for the biggest share of London's smoke, winds from the western side drift the smoke in a mass over the eastern suburbs. Approaching a manufacturing town by the air its position is marked by a great dome of mist and smoke. This may be seen from a tremendous distance and is often so thick that the town itself remains completely hidden. The dome of smoke is bent over more or less from the direction of any wind that may be blowing. Flying from Newcastle on one occasion, thick mist and smoke were found to a height of 3,000 feet when the aviator [1] suddenly emerged into perfectly clear air and brilliant sunshine and looked down upon the solid-looking smoke bank through which he had pierced. It is a curious experience to plunge back blindly into such a smoke bank, trusting that on

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[1] G. H.

Photo, [illegible]

descending close to the earth it will be possible to pick up bearings and find the landing place.

Something will be done ere long in the direction of aerial touring in large parties. Huge passenger-carrying machines are now being made with comfortable seating for four or five people, and it is only necessary to introduce a system of dual power-plant, rendering the chance of unintended landings extremely remote, for journeys on these machines to become common. The alternative engine is very necessary, for one dare not contemplate emergency landings in machines carrying more than two people. Such journeys have, however, been made. Mrs. Richard Gates narrates her experiences of a trip from Hendon to Brooklands and back in a Grahame-White biplane which, as it was one of the first cross-country trips of the kind, must be quoted.[1] The pilot was Mr. Grahame-White, and the machine carried five persons besides him. 'In the history of the world did ever a woman before traverse the aerial way with such an experienced crew?' writes Mrs. Gates. 'Mr. North occasionally moves forward to the pilot's seat and pumps more pressure, and ever and anon looks at various gauges, whilst taps seemed to be constantly turned on and off by Chapman, and Carr climbs round the engine, touching first one part, then another. A tool-box is pulled from under a seat by my husband, who takes string from it, cuts a length, and hands it to Mr. North, who moves forward and ties up a throttle-lever, and all the time we are moving through the air at the speed of an express train.

'As we pass over Hounslow Heath, innumerable tents are to be seen, looking like giant mushrooms, and to our right a monoplane is flying parallel with us. It is Brock, on an 80 h.p. Blériot, clearly silhouetted against the western sky. A moment later my attention is directed to a thousand feet beneath us, where flies a Maurice Farman, piloted by Noel, who carries a passenger, and, as I watch him there below us, Marty, on his Morane-Saulnier monoplane, like a huge brown hawk, flashes swiftly past. These are our escort, all bound, as we are, for the same destination—Brooklands Aerodrome. Five minutes pass, and the famous motor track, looking like a small white circle in its setting of trees, comes into view.

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[1] *The Aeroplane*, Oct. 9, 1913.

'Nearer and nearer we approach and now our pilot throttles down the engine and we begin to descend in a tremendous sweeping circle, whilst all the time our engineer heralds our arrival by tooting a powerful horn. This huge biplane, as steady as the proverbial rock, with never so much as the slightest tremor or quiver, seems as though it will never come down. At last, however, we are over the track and, with a skilful turn, our pilot brings us to earth so lightly that one hardly realises it until the engine stops. Down from our Clipper of the Clouds we get—one! two! three! four! five! six! The spectators look at us curiously, apparently wondering when the procession will cease.'

Of the return journey Mrs. Gates writes: 'We seem to have been in the air hardly two minutes when my husband points ahead into the fast-gathering darkness, and tells me it is Harrow. I can see nothing but inky blackness all round us, whilst lights begin to twinkle below us in all directions. They seem like myriads of fire-flies, for we are climbing, climbing, and still climbing, when there passes within thirty yards, and just below us, what looks like a beautiful white bird; it is Hucks on his 80 h.p. monoplane with a passenger; the latter waves to us and the former wheels his machine about and passes astern. A few minutes later he repasses and is soon lost to view in the gloom.

'Now we are over the Welsh Harp reservoir at 4,000 feet, and the Edgware Road is pointed out to me, showing like a long thread of flame as its thousands of street lamps flash below us. Surely that small, almost circular field cannot be the 220 acres of the enormous Aerodrome! It is, though; and now our engine is throttled once again and our pilot is bringing us down, down, down, slowly, but surely, to mother earth. We pass over old Hendon and my own house at 2,000 feet, the brilliant lights from the promenade at Golder's Green—a mile and a half to our right—showing up magnificently. On and on, over Mill Hill, we continue, slowly turning all the time. At last we are gliding straight into the Aerodrome, when Hamel, on his Morane-Saulnier monoplane flashes into sight and alights as easily as any bird, having travelled the twenty-odd miles at a speed of about 100 miles an hour. Now we alight and find that on the ground it is almost dark, and that Hamel, Hucks, Verrier, Brock, Baumann, and Marty have all returned.'

What limits aerial touring for pleasure is probably the cost, combined, as it was in the first few years of flying, and is now, although to a smaller extent, with a certain amount of obvious discomfort and uncertainty. The discomfort and uncertainty are steadily diminishing, but the cost of flying has, if anything, increased, this being due to a steady increase in the power of the engines used, involving greater fuel consumption and greater capital outlay.

The heavy capital expenditure upon machines and engines has, of course, been partly due to the fact that the purchaser has, one way and another, had to bear his share of the cost of experimental work. It is absolutely certain that the time for a cheapening of the means for mechanical flight is almost at hand, and it is extremely likely, moreover, that fuel for the engine will also become cheaper, not merely because this is demanded in the interests of flying, but for the reason that the even greater commercial needs of land and water transport have to be met.

Some idea of the cost of a big aeroplane tour in the early days may be gathered from an extreme case, that of Mr. G. Rodgers in his journey of 2,600 miles from New York to Kansas. This was in 1911. Mr. Rodgers did not, however, merely fly from New York to Kansas, but stopped at various places and gave exhibitions. The repairs to his machine during this remarkable tour cost more than £3,000. He had all sorts of engine trouble. Near Dallas while at a height of 3,500 feet his engine broke down, but he fortunately reached a good landing place, the only possible one within forty miles. Over and over again he broke wood in landing, for many of the landings were emergency ones. In his anxiety to complete the journey within a certain time he took great risks, on one occasion continuing flight in spite of the fact that some of the rollers of his propeller chain were weakening. At Colorado a cylinder broke and some splinters of steel entered his right arm, but he managed to plane down safely. He was followed throughout his journey by an aeroplane repair car on the railway. When he had finished, his machine was a mere patchwork affair. Oddly enough, nearly all his accidents happened on Sundays, and this so impressed Mr. Rodgers that he declared he would never again fly on the Sabbath. Mr. Orville Wright said that he must have been born with four horse-shoes in his pocket! The machine was a Wright biplane. Here is a list of the spares that Mr. Rodgers had to use: 6 back skids, 5 front skids, 8 propellers, 6 planes, 3 seats, 2 radiators, 6 cylinders, 2 steering rods, 1 elevator, 2 engines, 2 tails, 2 tail springs, 4 propeller chains, 4 back tail skids, and 4 fins. And the aviator got across, with whole bones, only to be killed by a sea-gull a few months later. Whilst he was flying at Long Beach, California, a gull got wedged between the tail and rudder of his machine, rendering the rudder immovable. The aviator came down, head on, into two feet of water.

An attempt will now be made to give an idea of the cost of aeroplaning. This will, of course, depend upon the type of machine used, and, obviously, light will be thrown upon the question by considerations referred to in other chapters; for example, in that dealing with the choice of a machine.

The cost of flying is made up of the capital expenditure upon the machine, the cost or rental of a shed, repairs and renewal of parts, fuel, and the wages of one or more mechanics. The price of a machine may be anything from £400 to £1,500. Taking the engine most generally in use at the time of writing, namely, the Gnome, the aviator may buy a single-seater machine with a 50 h.p. motor for about £700, or a two-seater machine with an 80 h.p. motor from £1,000. The cost of machines goes up steadily according to horse-power, but for ordinary touring purposes an engine of 50 h.p. single-seated or 80 h.p. for passenger-carrying is amply sufficient.

The cost of housing the machine varies according to circumstances. The usual rent of a shed in an aerodrome is £100 per annum. The wages of a good mechanic are from £125 to £175 a year, and it may be taken that, for a mechanic and a boy, the annual expenditure need not exceed £175 per annum, and should be kept down to £150. Added to these items must be that of insurance, and since this varies with the times, details need not be given here. It is, however, possible to insure against practically all risks taken in aviation, although the rates for damage to machines are rather high. The most important risks to insure against are those of fire in the sheds, and what are known as third-party risks. An aerial tourist is frequently compelled to come to land on fields under cultivation, and it is irritating to have to settle the claims of farmers and landowners on their merits. But in the case of trifling damage it is advisable whenever possible to settle with the owner on the spot.

It was held in a case of trespass adjudicated upon at Walsall[1] that the aviator[2] was not responsible for damage done by the crowd, since no wrong had been committed or intended by him.

The question of repairs is one that frightens the amateur even to think of, but, fortunately, without reason. Naturally, the costs are higher in the early days of a new industry, when it is difficult to standardise, than they will be in the future; but the cost of maintaining a machine depends almost entirely on the owner. One man's motor-car costs £80 a year, another's £500 a year, owing to their different methods of effecting repairs. One sends his machine back to the works to have a nut fitted and pays in guineas; the other does it himself and pays in pence. It is perfectly possible to-day for a pilot, provided that he is a handy man, to run an aeroplane with one mechanic only, and no man would be more suitable than his chauffeur. Plenty of people take a pleasure in doing their own repairs to a motor-car, and the repairs to an aeroplane are considerably easier, with the exception of those to the engine, which are of a similar nature to those of a motor-car. An aeroplane consists almost entirely of wood, steel fittings, fabric, and wire. With the exception of steel fittings, the work is one which can be done by any good amateur carpenter, and his pleasure in flying would be very much enhanced by the fact that he has done his own repairs. Steel fittings are not often broken, and when they are they are not costly to replace.

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[1] Walsall County Court, December 10.

[2] G. H.

The most ordinary repair will probably be a broken undercarriage, or a damaged propeller. If the owner is prepared to work himself—and he will find it extremely interesting—he will proceed, after having supported his machine, to take the whole undercarriage down, and carefully examine each part to ascertain the damage done. As a rule he will be surprised at the slight repair bill. What appeared a mass of damaged wire and wood gradually resolves itself into a number of parts, very few of which cannot be used again. But how different the repairs bill of the man who at once wires to his manufacturer for a complete new undercarriage! Even if two or three struts require replacement, and here is a case where application to the maker is very much wiser, the expense is not great. An examination of the fittings again will reveal the fact that very little irreparable damage is done. The same applies to a propeller: there are very few ordinary smashes to propellers where they are slightly chipped which cannot be put right by the maker at the cost of a few shillings, or a few pounds according to the damage, and with a very marked difference to the cost of ordering a new one. It is well to have a spare propeller, so that flying may continue while the repairs are proceeding. As to new struts, it may be taken on general lines that a new strut from the makers—the best form of stream-line hollow strut, beautifully made, well-finished and varnished, and fitting into its place to a millimetre—should not cost more than about £1, and one does not need new struts every day.

As regards the upkeep of his fabric, etc., this again is a question of how it is maintained. If patched neatly and properly when the canvas is torn, and suitably 'doped,' the machine will last a long time without recovering. Even this work can be done by the amateur, although, if he is not quite up to it, for the expenditure of £30 or £40, he can have his machine restored as new again. To re-dope a monoplane costs about £10. To re-cover a monoplane costs about £12. Apart from breakages, and given an owner is willing to work, the maintenance of an aeroplane is not expensive. Even a broken plane is not necessarily finished with merely because it appears so. Taken carefully apart, it may be found that, say, 75 per cent. of the ribs are intact, that all the fittings are capable of being employed again, and so on.

The difference between the man who orders everything new and the one who uses his brains and hands will be very marked. But the manufacture of new parts by aviators is not advisable—repairs certainly, but only with parts supplied by the maker. Some machines, as is well known, have been maintained for a few pounds. These are practically always in use for cross-country and aerodrome work. But the secret of their economical maintenance is management and proper care. A worn-out rubber shock-absorber, replaced at the right moment for a few shillings, will save a broken chassis costing pounds. Careless maintenance runs up the cost. Even careless adjustment, or want of adjustment, may result in the machine flying badly and, finally, the inability to get out of an awkward place may lead to a smash and expensive repairs. It is for all these reasons that it is

A VILLAGE IN POITOU

OVER THE CHAMPS ELYSÉES
(Showing a Wheel of the Under-carriage)

AMBOISE

HAUTS FOURNEAUX

A TOUR IN FRANCE
(Taken by M. Henri Roux from a Borel Monoplane)

impossible to give an average cost of maintenance. The old adage, 'For the loss of a nail the horse was lost,' was never more true than in the case of an aeroplane. It is not suggested that flying is a game for poor men, but there are plenty of men who, provided the capital outlay is forthcoming, could and should have their machines for private use.

Here is a list of the costs, apart from rent, but including maintenance of a machine which was used for cross-country and other work at week-ends and occasionally at other times. The total cost for eight weeks was as follows:

	£	s.	d.
Labour for repair, cleaning, etc. .	1	5	6
Material used	1	2	6
	£2	8	0

The repairs were of an average kind. They included taking down tank, repairing and replacing a skid, replacing shock-absorbers, adjusting the machine throughout, cleaning, etc. The distance flown in the period was 450–500 miles, which would be about the distance flown by an amateur using his machine in good weather at occasional times. The repair to skid and tank, and replacement of shock-absorbers were owing to a bad landing on bad ground, and generally the expenditure, apart from the real smash, is of an average description. Petrol and oil came to £5 14*s*. 11*d*., which, with the repair bill of £2 8*s*., equals a total of £8 2*s*. 11*d*., and works out, over the distance flown, say 475 miles, at about 4*d*. per mile. This is for running expenses, including ordinary maintenance. At the end of say 5,000 miles, for the cost of about £100, the engine might be taken down and sent to the makers to be overhauled, and the machine might be thoroughly examined and put in good repair. This, however, would leave the machine fit for another 5,000 miles, so that the expenditure of £100 would be spread over 10,000 miles and would then work out at 2½*d*. per mile, or a total cost of 6½*d*. per mile flown, apart from rent and mechanic. If a shed could be put up on a private field and the mechanic were the owner's chauffeur, it is evident that the ownership of an aeroplane is not such a terrible business after all.

The fuel and oil of an aeroplane of high power, that is to say, a machine having a motor not less than 80 h.p., cost about £1 for every hour of flight, during which it will travel about 70 miles or more. The Gnome motor of 50 h.p. uses in one hour about five gallons of petrol and one and a half gallons of castor oil. An 80 h.p. Gnome uses seven gallons of petrol and two gallons of castor oil. At the time of writing the price of petrol is 1*s*. 7*d*. per gallon, that of the best castor oil 7*s*. 6*d*. per gallon.

The principal advantage that castor oil possesses as a lubricant for rotary engines is its comparative volatility. True, it is technically a fixed oil, that is to say it is not volatile until resolved into its constituent elements. This, however, occurs to some extent when used as a lubricant for motors. Universal experience shows that castor oil is the best available lubricant for aero-motors, particularly those of the rotary type, but it is far from being the ideal lubricant, and tests are constantly being made with a view to finding something more efficient. Incidentally it may be remarked that the purer the castor oil the better does it perform its functions. The purest castor oil is a vegetable product obtained by pressing the seeds of the castor oil plant; the crude oil is then refined. Various grades are made. Pure castor oil is completely soluble in its own volume of absolute alcohol, which test can be made by any aviator who doubts the purity of his lubricant.

The cost of fuel depends, of course, upon its price at the moment. Of a number of technical calculations arising out of the performances of the aeroplanes that passed through the War Office Competition in 1912,[1] one of the most interesting related to fuel and oil. 'The cost ranged from 1½*d.* per mile to about 4*d.* The most economical was the Avro. The Cody cost about 2½*d.* per mile. These figures are very surprising; taken with other considerations, they show that the cost of aviation should be by no means excessive. In the first place, the cost of tyres, which in motoring is so serious a factor, is practically negligible in an aeroplane. The engine, it is true, costs rather a lot, and is usually hard worked. But a reduction in the cost for ordinary powers in the near future is certain. As regards the working of the engine, it is to be remembered that, in some respects, it is not so hardly treated as is the road motor, for it is not subject to violent acceleration and there is no brake; again, there is no transmission gear to speak of.

'On the score of speed, of course, the aeroplane has a big advantage: and not only is it much faster but its path is direct. Speed in relation to cost is shown in the following table:—

	Miles.		Miles per hour.		Per Mile per hour.
Avro . . .	100	at	62	at	2¼*d.*
Hanriot . .	,,	,,	75	,,	4¾*d.*
Maurice Farman .	,,	,,	55	,,	5½*d.*
Cody . . .	,,	,,	72	,,	3½*d.*

The machines, it should be remembered, were carrying the full "Trials" loading.

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[1] *Flight*, September 7, 1912.

'On the score of range of action the Avro again excels. Indeed, it is very remarkable how generally this little and inexpensive biplane, driven by an all-British engine and containing some noticeable innovations in design, proved its merit. Even with the "B.E.2" the Avro compares very well indeed; but the "B.E.2" had the advantage in engine power and was a machine on which the very fine pilot who drives it had obtained much valuable experience.'

This matter was further elucidated in an article and tables in *Aeronautics*.[1] From this article it will be seen that the stationary engine has a great advantage over the rotary engine in the matter of fuel consumption, for although the latter is lighter in construction than the former, where long distances are concerned the balance is in favour of the stationary engine. For each 100 lb. of petrol and oil the following distances could be travelled by the respective aeroplanes. The table is based upon the greatest speed the machine attained during competition.

Aeroplane.	Motor Type.	Range of Action.
Cody	Stationary	107·5
Deperdussin	Rotary	96·6
Hanriot	Rotary	96·8
Maurice Farman	Stationary	99·3
Blériot	Rotary	116·0
Deperdussin	Rotary	80·4
Bristol	Rotary	98·8
Avro	Stationary	173·1

It is evident then that, taking into account the capital cost and the running costs, aerial transit for commercial purposes cannot pay at the present time, but a gradual reduction of the costs under all heads is certain. For military purposes the cost is, however, of secondary importance, but, in the business of preparing the Royal Flying Corps for its duties, expenses under the heading 'fuel and oil' make a far bigger item than many people suppose. On the assumption that there are 150 aeroplanes in constant use and that each machine is responsible for no more than 200 hours of flying in the year we get an annual expenditure on fuel and oil of £20,000 at retail prices. When the number of machines in use in the Services is more than a thousand, and in addition there is a large fleet of dirigible balloons, the taxpayer will have reason to take a keen interest in the prices of petrol and lubricating oil. A great amount of attention is being given by experts to the substitution of a cheaper fuel for petrol, and there can be little doubt that in the very near future the running costs both of motor cars and of flying machines will be reduced fifty per cent.

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[1] *Aeronautics*, September, 1912.

The cost of transit of an aeroplane by rail must be taken into account although it is an item that does not greatly concern the average amateur flyer. In the case of a machine that can readily be transported by road on its own wheels, road transport for short distances, at any rate, is the best. As to rail charges they work out at about 1*s.* 2*d.* per mile. Aeroplane transit by rail is, however, scarcely likely to become common.

To the aerial tourist it is important to be flying a machine than can be easily stowed away in the ordinary accommodation provided by a farmyard. In this respect the monoplane has a decided advantage over the biplane, for the wings can be taken down in less than half an hour and the whole machine put under the roof of a barn or even in a motor garage. Not only is the biplane an altogether bigger craft, but the process of stowing it away for the night is much more complicated. This, however, is a disability of the biplane which designers are seeking to remedy.

In touring, it is well to remember that it is far easier to obtain fresh supplies of petrol than of castor oil, so that at the outset of a journey it is important to map out the route to be taken, and unless a halt is to be made at a large town, to carry a reserve of castor oil or to have it ready at depôts. Petrol can be obtained whereever there are motoring roads, that is to say throughout the United Kingdom and over the greater part of the Continent. The quality of the petrol need not greatly concern the pilot, that used by the motorist being all that he requires. Of course there are differences—certain fuels of relatively low specific gravity fouling the cylinders more quickly than the heavier qualities.

Very little remains to be said of practical value to the aerial tourist. One little difficulty that is constantly encountered is that of getting the machine started up when you have not your mechanic at hand. Many machines, of course, have self-starters. On the other hand, some of the most popular types have not, nor do the pilots concern themselves about what they regard as a non-essential. The attitude of the average pilot towards such conveniences as self-starters and silencers is that these will come in good time, but that at the moment the important matter is to be able to fly efficiently and securely. In the case of a two-seater, the operation of starting may quite easily be done without external aid. The pilot or the passenger can take his seat in the machine, the other remaining outside to give the propeller a turn. The engine having been started, the occupant of the machine keeps it going by switching on and off so that there is not sufficient pull to get the machine under way. Meanwhile

CANTERBURY

CAPE GRIS NEZ

NEAR ARRAS

ARRAS

A TOUR IN ENGLAND AND FRANCE

(Taken by M. Henri Roux from a Borel Monoplane)

THE NEW YORK
PUBLIC LIBRARY

his companion gets into his seat, the engine is put full on, and the ascent made. Where there are intelligent bystanders, however, it is always an easy matter to ask their aid. In all districts where aeroplanes are not familiar playthings, it will be found very necessary to explain with great care what is to be done. If these precautions be observed no difficulty will be encountered. It is owing to the carelessness of aviators in this respect—for many of them have assumed that a casual bystander has not to be told with great minuteness, not only what he has to do but what will happen when he has done it—that some unfortunate accidents have occurred. It is most necessary, having obtained willing helpers, to explain very carefully the operation of waiting for the word to give the propeller a turn, of turning it with a good swing and immediately jumping clear. It is further necessary to explain that the turning of the propeller, if effectual, results in the engine going at a tremendous speed and making a great noise and wind that are quite likely to alarm those who are not accustomed to them. It is necessary also to tell the bystanders that the machine will almost immediately plunge forward and that to stand in its way is to court danger. All these instructions apply also to any willing helpers who may be found to hang on to the tail of the machine. These may be dispensed with, especially when the switching on and off process is adopted, but if they are employed it is most necessary to tell them that the starting of the engine causes a great wind behind the machine, but that they must await the signal to let go before stepping clear. All this sounds very complicated and arduous in the telling, but it can be accomplished quite easily by any peasantry in any country, even if they have never seen a machine before. It will often be found advantageous, however, to dispense with external help and start the machine in the manner described by switching on and off.

The uncertainties of aerial touring are very few. With proper care engine trouble can be reduced to a very small amount. As to the weather, good pilots now go out in anything short of a gale or fog, nor are they troubled to any very great extent by heat eddies. There must be very few days in the year when flying is not possible; and that aerial touring will develop and extend is absolutely certain with the cheapening of machines and the increase of the general facilities mentioned, in the chapter on the Future of Flying, as likely to come in the near future.

As to the sport of flying: no one who has experienced its delights needs to be told of them. It is more exciting and exhilarating than anything else, and the very hardships and difficulties which it has entailed in the past and must continue to entail in some measure, form part of its charm and interest.

In the early days of flying aerial tourists had experiences amusing and terrifying, the story of which would fill many volumes. In a description of a passenger flight from London to Paris, Miss Trehawke Davies said:[1]

'The first part of the journey, to Rochester, was perhaps the most disagreeable, and I was afraid Mr. Hamel would give it up, as the wind was strong and very gusty, and bothered us a lot. As soon as we passed Rochester, however, it was glorious. We went at an average height of between six and seven thousand feet. I was in charge of the pressure pump for renewing the petrol supply, but it requires a good deal of force, and I have never been very muscular. It was only last Thursday that I was out of the hands of a hospital nurse, and I was still not very strong. This may not be an excuse, but it is the reason that I seem to have failed. I must say, however, that I ought to have had several pairs of hands, because I had always to have one finger on the map to keep it in place, and another on the pressure pump, besides having all the time to keep pulling up Mr. Hamel's fur gloves, which would slip down over his wrists.

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[1] *Evening Standard*, April 4, 1912.

'As we got over the Channel, suddenly the motor stopped, and I was surprised to see that we were coming down in a magnificent vol plané, and from 6,000 feet circled, swooping downwards in diminishing curves, looking for somewhere to land. After corkscrewing once or twice over a hummocky field, we alighted safely near Cape Grisnez, and were soon surrounded by the peasants. Mr. Hamel found a bicycle, and went off to Ambleteuse, leaving me to myself. The peasants wanted me to go and have coffee, and a Customs official arrived and asked where I came from and if I had anything to declare. I told him that I had nothing but what I stood up in, and as for declarations, the only one I had to make was that I was rather cross at the accident. After a while Mr. Hamel came back, and after examining our Blériot found that there was nothing wrong except that I had not pumped hard enough to supply the motor.

'We then made off to Hardelot, where M. Blériot has a property, and where we always intended to stop. There we had a good breakfast and rested for an hour or two before renewing our flight. We left at about a quarter to four, and in spite of a stiff breeze came along merrily. I, for one, was very glad to see Amiens Cathedral like a toy underneath us, and to know we had done about half of the distance. Then we remarked the white towers of the Sacré-Coeur at Montmartre, and the Eiffel Tower, and a few minutes after were once more planing down in a splendid sweep at Issy.

'I was never really cold, although I was dressed just as I am now (in a sealskin loose mantle and small felt hat, with low shoes and silk blouse). Of course I wore goggles, but that was all in the way of special protection.'

CHAPTER VIII

WINDS, EDDIES, AND OTHER DISTURBANCES

VERY soon after his first flight the aviator begins to understand that the air is a very impressionable element, its movements and moods answering in many strange ways to the conformation of the ground, to the quality of land and sea, and even to the colour of vegetation. The field of exploration opened up in this direction appears almost illimitable, and it is only possible here, after reference to the more familiar phenomena, to suggest inquiry into less-known manifestations that still wait scientific explanation.

Even in dealing with the four primary winds—those from the north, west, south, and east—differences in quality are found, apart altogether from any question of strength, and it is perfectly natural that the vehicle for mechanical flight, sustained in and dependent upon the atmosphere, should be more sensitive to its condition than machines and creatures that never leave land or water. In Great Britain the prevailing air currents are from the south-west ; then winds from the north-east and east are frequent ; but experience soon tells the aviator that his machine is as sensitive, in respect of the efficiency of his planes and of his engine, to the quality of the wind as any weather-sensitive mortal. As a pupil he will have learned to have more affection for winds from the westerly side than for those from the eastern half of the compass, for it is a fairly general experience that at sunset a westerly or south-westerly wind, unless it be a storm, declines in strength; whereas those from the opposite quarters do not. This fact which is, of course, of supreme importance to all aerial navigators, is particularly interesting to the pupil. He is not permitted to take charge of a machine in anything like a breeze. The pupil's first acquaintance with flying is generally, in Great Britain, extremely disappointing, for the reason it so often happens that he is compelled to wait for long periods for a flight. As he becomes stronger on the wing, however, and begins to fly across country, he observes another difference between the two main wind streams of Great Britain, and he will gradually acquire a preference for those from the east and north-east. Winds from the west and south-west are usually more or less humid and relatively warm. Under the influence of these winds in the summer-time the earth is more 'active,' and the aviator encounters more eddies and other irregularities.

Effects of temperature and humidity are further considered in the chapter on Weather, but, as already said, these depend to a large extent upon the direction of the wind. The east wind, which is said to be good neither for man nor beast, appears slightly to favour not only the working of the engine because it is dry and in many cases cool, but it is very often accompanied by a high barometer, evidence of increased atmospheric density giving some slight increase of lifting efficiency to the planes. Further, a difference of temperature of one degree Centigrade involves a difference in atmospheric density of 0·366 per cent. But as flying machines are almost invariably equipped with power considerably in excess

NEARING ORLEANS

LA CHAPELLE

IN ARTOIS

ARTOIS

A TOUR IN FRANCE

(Taken by M. Henri Roux from a Borel Monoplane)

of actual flying needs, little differences of this kind are not very important.

Having far greater effect are irregularities in the strength and direction of the flow of the air to which, until the navigation of the air became practicable, comparatively little attention was given. Indeed, except to sailors, these irregularities count for little, but the aviator is sensitive to unevenness in the wind that would be disregarded by the mariner. Save at a fair altitude an absolutely evenly flowing wind is very seldom found, although at times over the sea the wind appears to blow with fair regularity at a height of 100 or 200 feet. Over flat land, too, the pulsations of the wind are usually not very marked. There is no absolute rule as to the amount of pulsation, but repeated and careful observations of meteorologists show that the strength of a wind varies seldom more than 30 per cent. of its average velocity. In some conditions, however, brief periods of dead calm alternate with gusts of thirty or forty miles per hour, the weather report stating that the strength of the wind was, say twenty miles per hour. Now, whereas a steady wind of twenty miles per hour would scarcely bring a small twig down, a gust of wind of thirty miles per hour may break off a big branch. The aviator who never before concerned himself seriously with questions of wind velocity becomes, soon after enrolment as a pupil at a flying school, a devoted student of the anemometer, an instrument to be found in every aerodrome, and it will not be long before he realises that this instrument of precision is very unkind to the pilot who desires to shine as a good wind flyer. The forty mile wind Jones claims that he weathered may turn out, on reference to the anemometer, to have been a breeze varying from fifteen to twenty miles per hour. But the anemometer only records the strength of the wind blowing near the ground, and the twenty mile wind on the ground possibly means a thirty or thirty-five mile wind at a height of 500 feet; so that, after all, Jones may have been right. Exaggeration has naturally marred the accounts of certain flights, but taking the history of flying all round, it will be found that aviators have flown in quite as high winds as recorded. When an aeroplane flying upwind is observed to be making no more progress than a man walking, and it is known that the speed of the machine is not less than fifty-five or sixty miles per hour, it is perfectly clear that at the height at which that machine is flying the wind is a gale of a least fifty miles per hour.

The diagrams traced by the needle of the anemometer afford surprising evidence of the strength of gusts. One such diagram, published by Prof. Langley, of a wind whose mean strength was twenty-four miles per hour, shows that in the space of one minute the strength of the wind fell from thirty miles per hour to zero, then increased to twenty-two and going down and up and down again, fell to eight miles per hour. Wind of this character can only be tackled by an experienced aviator on a good machine.

The cause of unevenness is chiefly the breaking up of the wind by hills. High buildings also cause disturbances in their neighbourhood. Sometimes these irregularities are met at a considerable height, depending upon the strength of the wind and the cause of the irregularity. Further complications are caused by deviations in the direction of the wind laterally, in some cases by as much as 20 per cent. of the mean direction; and added to irregularities in strength and lateral direction are the upward and downward, slanting, and even vertical currents caused by steep hills, and set up by variations of temperature. Warm air rises and cools air descends, and where the surface of the land is diversified by woods and water, and where the land adjoins the sea, conditions are set up that cause slanting and vertical currents, constant or variable, the air ever seeking uniformity of temperature and density. Further, many of the movements set up in the air by variations of temperature take the form of vertical eddies, sometimes of a violent character.

Upward currents can be of almost any size and intensity. This is proved by the gigantic masses of water lifted in waterspouts, and by the removal of iron roofs from buildings, and their transportation to a considerable distance by the 'wind devils' of Australia. Besides vertical eddies, there exist horizontal eddies, small sections of air travelling in corkscrew fashion, and balloonists have seen the evidences of this in the movements of clouds.

Irregularities arise in high altitudes from the friction of two layers of air moving in different directions, when air waves are formed, causing an aeroplane to rock. The top and bottom surfaces of clouds often indicate the existence of air waves of huge extent.

'Aeronauts,' wrote the Rev. J. M. Bacon, 'looking down on the wind-swept surface of the clouds have observed these surfaces to be thrown into a series of rolls of vapour which are but vast waves of air. The interval between the successive crests of these waves has been estimated at half a mile.'

Sometimes a wind of sixty miles per hour will flow with perfect regularity and the aviator, although of course drifting to the precise extent of the current of air, flies with perfect steadiness, and has little work to do with the controls. But the aviator in the British Isles should remember that the wind in these regions is never steady for very long at a time, either in strength or direction. To a craft whose sustentation in the air depends upon its speed variations of the kind indicated are, clearly, very serious.

Aviators have built up a jargon describing these unseen movements of the air which cause their craft to perform strange antics. There is, for example, the 'hole in the air' obviously encountered when a machine without any visible cause drops plumb twenty, thirty, or fifty feet in the course of its flight. In the early days of flying careless speakers and writers have referred to this condition as a vacuum in the air; needless to say, a vacuum cannot exist in an element so perfectly fluid and extremely elastic. Even small deficiencies in the density of the air, relatively to neighbouring regions, are swiftly made up. But the expression 'hole in the air' very aptly describes the condition which causes the machine to fall. It may be due to one of several causes. If a machine flying with the wind is overtaken by a strong gust it cannot, owing to its inertia, instantly conform itself to the increased speed. Its speed relatively to the air is suddenly reduced. It may be reduced by as much as twenty or thirty miles per hour, and, although this reduction is only momentary, the machine loses altitude since its sustentation, which depends entirely upon its speed through the air, is suddenly in part withdrawn. The pilot is flying with just so much engine power as will keep him in horizontal flight, but this may not be the full power of which his engine is capable, and he can by opening the throttle obtain the increased speed necessary to overcome the loss of speed due to the following gust. But he could not be quick enough to correct the loss of altitude at the moment it occurs, and if he desire to recover the lost altitude later he will ascend at any convenient time. But it is highly probable that, following the gust, there will be a corresponding lull, and the effect of flying down wind into a lull has precisely the opposite effect to that already described. In other words, owing to the inertia of the aeroplane, which carries it on at whatever speed it may be flying, the lull in a following wind has the effect of a sudden increase of the machine's speed relatively to the air; and the aeroplane is at once borne upwards. Flying in a gusty wind, either with or against it, involves a continual rising and falling in the machine's course. Flying up-wind and meeting a gust causes the machine's head to rise, and if a lull follow the gust there is a corresponding dip. As a rule these rising and falling motions are not very serious, although in extreme cases pilots have been lifted slightly off their seats, so sudden has been the drop. When a machine is on a down slant, however, the head gust causes it to dip more steeply, for it strikes the top of the plane. Another effect of the overtaking gust or the opposing lull is propeller 'racing.' There is a rapid increase in the number of engine revolutions per minute, and, directly after, a corresponding decrease to normal. The reader is referred to the remarks on gusts in Chapter IV.

The extent of the rising and falling is clearly dependent upon the machine's speed. For example, if the pulsations of wind amount to twenty miles per hour, their effect in suddenly adding to, or subtracting from, a machine's lifting power is greater in the case of a sixty miles per hour aeroplane than in that of an eighty miles per hour machine. In the former case the variation is some 33 per cent., in the latter no more than 25 per cent. But from this it must not be assumed that the slower machine is necessarily less safe than the fast one. A machine that rolls and pitches considerably may be easier to manage and safer than one that is less visibly affected by gusts. In a violently pulsating following wind the aviator may have trouble in keeping the tail of his machine down, as each gust lifts the tail. This experience is by no means pleasant; the tail goes up, and down goes the head and one side of the machine. In this connection, as already remarked, the prevalent impression that an aeroplane should never fly in a wind of greater velocity than one-third of its own independent speed has no foundation on experience. It depends entirely upon the nature of the wind and the quality of the machine. It is often possible to fly in a wind very nearly as fast as the speed of your machine.

It is dangerous to fly near the earth in gusty conditions, as the sudden dropping of the machine or the dipping of its nose may land the aviator roughly on the ground or against some obstacle before can steer clear, and, in the case of a descent with engine stopped, skill is required to avert a bad landing which, indeed, cannot always be avoided, for coming down against the wind and when perhaps not more than fifty feet from the ground, if a sudden lull be encountered the machine may drop and reach the ground before the gliding path can be resumed. In rough weather the pilot should be able to count on his engine at any moment when preparing to alight.

Researches are now being made into the variations in the direction of air currents. At South Farnborough it has been observed, with instruments near the ground, that the usual deviations from the horizontal in normal conditions amount to as much as twenty degrees. In one case, during a wind averaging twelve miles per hour, deviations were noted ranging from twenty-one degrees in an upward direction to forty-three degrees downwards. In other words, the latter meant a downward wind of eight and a half miles per hour, and the effect of such a current upon any aeroplane would be disastrous unless the machine were at sufficient altitude to enable it to fly beyond its perilous situation. Probably, such extreme variations are not so likely to be met at flying heights.

A practised cross-country pilot is able, to some extent, to read the signs of the ground, and bearing in mind the direction of the wind he is often able to foresee whether he will encounter downward or upward currents, but he cannot always observe the signs so truly, nor can he tell when he may meet slanting currents set up by variations of temperature and many other causes which, perhaps, are not yet properly understood. A strong wind may deflect from the side of a hill and cause an upward current, felt at the height of 1,000 feet or more. These conditions, however, are not necessarily dangerous. Aviators are often surprised at the rate of climbing, or on the other hand at the difficulty in gaining altitude, when the engine is running quite normally. No doubt the cause is upward or downward trending currents of air.

Mr. Griffith Brewer has related some of his experiences while ballooning, which are valuable for the light they throw on upward currents. The conditions of which he speaks[1] occurred during thundery weather. He says: 'After being in the car for nearly an hour in sight of the Crystal Palace, a large upward trend of wind lifted us several thousand feet into the air. The speed of the upward trend may be imagined, when light objects thrown out of the car would rise in the air above the balloon, which itself was rising in the air. This was proof that the upward current was sufficiently strong to carry these small objects swiftly upwards, faster than it could carry the balloon up, because our instruments showed, by decreasing pressure, that although we had a big descending force, yet we were being lifted up by a strong vertical wind.

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[1] *Flight*, May 11, 1912.

'When the lift ceased at about five thousand feet, we descended in undisturbed air to our original level, and then, finding a northerly breeze, we travelled down towards Reigate, and when within four miles of the town, we were again picked up by a violent upward current which carried us up to five thousand feet. During the ascent the neck rope of the balloon was lifted up, and it was as much as we could do to pull the neck down so as to prevent the balloon becoming too much of a parachute, and there was a considerable amount of noise and disturbance with the flapping of the balloon and fabric generally during that upward rise. We wasted a good deal of gas on that ascent, and when we came down we found that we were in a violent wind and we made a somewhat rough landing.'

He adds some reflections upon the structure of moving air: 'In thinking these vertical currents out afterwards, I came to the conclusion that although we had not experienced any down currents of similar magnitude to the up currents, yet the air could not go up without a similar quantity of air going down, and I thought it was possible that similar down currents existed which, by accident, we had not encountered. In fact, I came to the conclusion that the wind currents might travel in the form of a vertical parallelogram, and that, if we had got into the down current, it might have been with disastrous results. Ever since that time, however, although I have encountered up currents of

POITIERS

CASTLE IN POITOU

BLOIS

AMIENS

A TOUR IN FRANCE

(Taken by M. Henri Roux from a Borel Monoplane)

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TILDEN FOUNDATIONS.

a less pronounced character, I have never found any down currents of similar speed to the up current.

'This leads me to the conclusion that an up current may be of a very powerful kind in a small area, which is fed not by a similar small area down current, but by a general descent of the main bulk of the air. For instance, if in an area of a thousand acres an up current of one acre sectional area takes place, and it is fed from the whole thousand acres, it follows that the speed and amount of down current, in being distributed over the whole thousand acres area, must be a thousand times less in distance of travel and in speed, than the distance of travel and speed of the up current, which is a thousand times smaller in sectional area.

'This may probably be the structure of the majority of up trends of air which become inverted, cone-shaped above and cone-shaped below, partly because they must expand as they get into a lesser pressure upwards, and partly because they rotate as they rise.'

M. Santos Dumont also relates a ballooning experience in an upward current. He writes: 'I let the balloon come down, hoping to find a safe air current, and when within 300 yards of the ground near the Var, I pulled the valve open and let out more gas. I could not go down. I glanced at the barometer and saw that I was ascending. I was being lifted by an enormous column of air rushing upward. It became necessary to save all the gas I could, and I abandoned the attempt to descend. I was dragged up to a height of 10,000 feet, and was compelled to wait the course of events.'[1]

It would be possible to give hundreds of experiences of flying in bad weather in the neighbourhood of mountains, but one will suffice. Mr. H. G. Hawker, flying in a

[1] *My Airships*. M. Santos Dumont.

hydro-aeroplane through the Caledonian Canal during his attempt to win a prize for flying round Britain, said: 'At the entrance to the first of the narrow places we were bumped about so terribly that we could scarcely keep our seats. Some of the gusts took us square, rocked us sideways, and twisted us round, the wind smashing like a hurricane against the body and the rudder. On each side of us were mountains 2,000 feet high, and deep gullies between them out of which cross-winds came roaring. Besides that we had a wind of thirty miles an hour blowing dead in our teeth. It was impossible to control the machine. I just had to "let her rip." Sometimes we were 1,500 feet up, sometimes we sank to 400 feet. I could not control the height at all. At times we went for four or five miles at no more than 400 feet up, trying to climb all the while, but unable to do so owing to the down-draught from the mountains. And all the time those merry bumps sideways. Some of the gullies I could see before we reached them; generally I could not, and the first I knew of them was the bumping.'

The effect of vertical and slanting currents on the flight of an aeroplane is very marked. If a machine be flying at such a speed that its surfaces force the air downward at, say, ten miles per hour, and it plunge into a downward current of four or five miles per hour, the machine will be carried earthwards almost irresistibly. To rise superior to these circumstances it is necessary to have a considerable reserve of engine power, and no doubt a line of development in flying machines will be the provision of power plant capable of giving great and sudden acceleration. In most cases the downward current is soon passed and normal flight resumed, but in a high wind the air sweeping down the lee-side of a big building or hill may not only be very powerful, but cover an extensive area.

Water has a cooling effect on the air above it, and over every river and pond is found an eddy due to Nature's continual process of equalising temperature. An aviator soon anticipates these disturbances by observing the character of the country, but some of the causes which produce eddies are not visible. As a rule, an eddy is not very embarrassing save to the novice. Its effect upon the machine is to cause it to oscillate or roll in certain well-defined ways, of which some attempt at classification, to be explained later, can be made. Certain eddies are constant. Every aerodrome has its regular difficulties of this kind, and it is not uncommon to find that the better known of them have been named. For example, over a well-known wood near the flying ground at Larkhill, on Salisbury Plain, there is an eddy, found in all weathers and at all hours, known as 'Aunt Sally.' The precise point at which an eddy may be met varies slightly according to the direction of the wind, the effect of wind evidently being to bend the invisible whirlpool aslant. What the aviator cannot always observe from above is the difference between damp earth and dry ground. The ground below which at a very little depth exist considerable quantities of water, does not necessarily have any indication of the fact, yet almost invariably the aviator, over such a spot, will find the air disturbed. One can almost imagine that the water diviner of the future may be a flying man, and not the gentleman with the forked hazel wand. Clusters of trees create eddies of air owing to their coolness as compared with open country. The eddies from ponds and rivers are sometimes felt at a great height. Eddies are found over white roads, moving trains, and chimney stacks.

In addition to eddies caused by permanent features of the landscape there exist on most days of the year conditions which set up eddies. These are due to the diurnal changes of temperature, particularly on days when the variations between the cool of the night and the heat of the day are very marked. After a heavy dew the rising sun causes tremendous activity in the air near the ground, due to evaporation from the dew-soaked earth and its warming. In winter, when the dew takes the form of white frost, the air for an hour or two after sunrise is in a disturbed condition for flying, although this condition is not perceptible to the pedestrian. In the early days of flying even experienced pilots declined to make ascents while these conditions obtained, or indeed at any time during bright sunshine, but only the pupil nowadays need be prevented from flying through morning eddies. On a very hot day an experienced pilot may be to some extent embarrassed by the bigger eddies he will encounter, and will generally be found to agree that it is preferable to fly in a strong and fairly steady wind than in 'calm' air at mid-day during a heat wave.

Crossing from land to sea under ordinary flying conditions one passes from rough air to smooth, although the wind over the sea is usually stronger. It must, of course, be remembered that to the airman wind is a relative term. If the wind be steady it is merely a body of calm air in motion. Accordingly an aviator will often speak of rough air when the flags hang limp, and he will go aloft quite cheerfully at other times in a thirty or forty mile wind. Fishermen are full of weather lore, and they attribute much to the influence of the tides. On certain parts of the coast at certain hours of the day peculiar conditions are encountered. In a flight from Penzance in dull weather the aviator[1] ascended above the mist and for a long time was out of sight. He could see Land's End in the distance. Later, on descending to a low altitude close to Land's End where the wind, blowing off the land, evidently met air currents from the Atlantic, his machine was tossed about considerably, now up and now down, and was very nearly driven into the water.

A curious feature of the difference between the wind over land and over sea is that, in the early morning in calm weather, while the sea mists are being dissipated by the sun, a reversal of the ordinary contrast is sometimes experienced. Over land, although a certain amount of trouble may be found with small eddies, the air is relatively smooth, but on flying above the sea the aviator is much tossed about. As already remarked, when there is any wind blowing it is steadier over sea than over land.

In all these disturbances of the air the aviator has nothing to fear unless he be near the ground. The process of landing is sometimes difficult where there are eddies or any gusty wind, or in the neighbourhood of houses and trees. Most aviators solve the problem by descending very steeply in order to have plenty of 'way' on the machine. If, on approaching the ground, the machine is tipped sideways by a gust or an eddy there is far more chance of getting it into control if it be travelling fast than if it has spent its force at the end of a vol plané. In very bad conditions it is well to come down steeply, if the engine be stopped, when you have to land in a small place enclosed by trees or between hills. It is, however, far better to have your engine running. The experience of an aviator[2] when flying at Ranelagh, in the presence of the King and Queen in June 1912, afforded an instance of the rule here given. Ranelagh is an extremely difficult place to land in at any time owing to the high trees all around. On that day there was a strong wind, and the available landing area was just in front of the spot where the Royal party had assembled. Near the ground a very bad bump was experienced, the trees were only just cleared, and indeed, for the last few feet of the descent, trees were on either hand.

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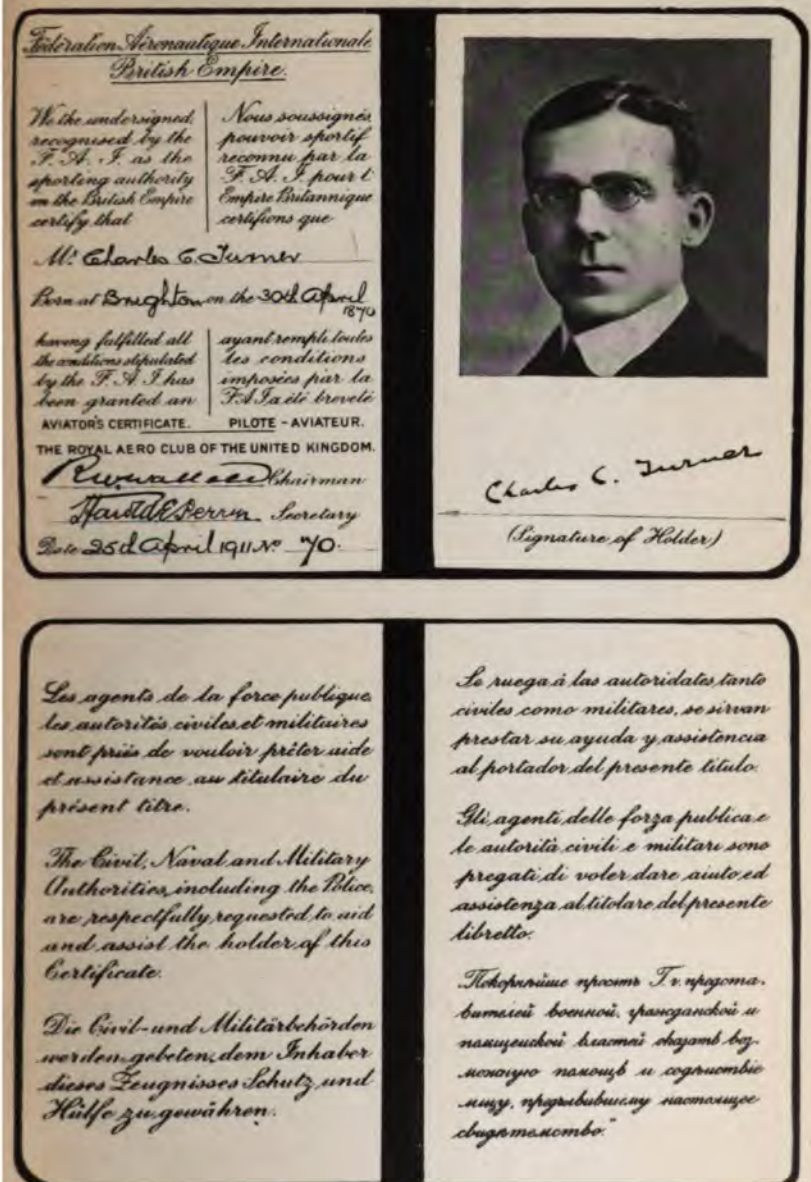
[1] G. H., September 1913.

[2] G. H.

The reader may have gathered the impression that eddies are found only near the ground, and that in all cases they have a direct connection with the shape or condition of the earth below. This is far from being the case. Not only are eddies from the earth found at a great height, but a whole series of air disturbances are set up by clouds, so that, although it is common to assert that an aviator finds smoother air aloft, there are many occasions when in ascending he will pass from smooth conditions to very rough flying. When the sky is covered with patches of cloud alternating with the blue the aviator is certain to encounter difficulties until he gets over the cloud region. Invariably under blue sky but over a cloud-field the air is smooth, but he will almost inevitably find a very great difficulty in climbing through the clouds or between them. The reason apparently is the constant flowing to and fro, and up and down, of the air in its endeavour to equalise the temperature of the cool air below the patches of cloud with the relatively warm air between them. A number of experiences appear to point to the fact that in these conditions there exists between the cloud patches, that is at every patch of blue sky, a downward current. It is sometimes absolutely impossible to climb through the clouds ; at every attempt the machine is driven downwards. In a flight from



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We the undersigned recognised by the F. A. I. as the sporting authority in the British Empire certify that

Nous soussignés pouvoir sportif reconnu par la F. A. I. pour l'Empire Britannique certifions que

Mr Charles C. Turner

Born at Brighton on the 30th April 1870

having fulfilled all the conditions stipulated by the F. A. I. has been granted an

ayant rempli toutes les conditions imposées par la F. A. I. a été breveté

AVIATOR'S CERTIFICATE. PILOTE - AVIATEUR.

THE ROYAL AERO CLUB OF THE UNITED KINGDOM.

R W Wallace Chairman

Harold E. Perrin Secretary

Date 25d April 1911 No. 70.

Charles C. Turner

(Signature of Holder)

Les agents de la force publique, les autorités civiles et militaires sont priés de vouloir prêter aide et assistance au titulaire du présent titre.

The Civil, Naval and Military Authorities, including the Police, are respectfully requested to aid and assist the holder of this Certificate.

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Se ruega á las autoridades tanto civiles como militares, se sirvan prestar su ayuda y asistencia al portador del presente titulo.

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Покорнѣйше просятъ Г.г. представителей военной, гражданской и полицейской власти оказать возможную помощь и содѣйствіе лицу, предъявившему настоящее свидѣтельство."

THE FOUR PAGES OF AN AVIATOR'S CERTIFICATE

Dover to Cologne[1] rain storms, alternating with bright sunshine, were encountered. The effect was extremely beautiful and impressive, considered as scenery. At times there was heavy rain to right and left while the machine was bathed in dazzling sunshine, at times plunging in and out of detached bits of clouds; the sea in the Channel was very rough, in patches green, but here and there swept white over an area of four or five miles by a squall. But it was impossible to climb out of the rough air, far rougher than the sea, into the region of calm that certainly existed at a height of no more than 2,500 feet, and so it was necessary to labour along at an altitude that was not sufficiently great for such a journey.

Flying after a while in a stormy wind becomes extremely arduous and the pilot looks forward to the end of the journey. It is a good plan under these circumstances temporarily to lessen the labour of piloting by turning the machine until the wind is abeam, in which position it is far more easy to keep level than when flying with or against the wind; in other words, when it is a question of constantly manipulating the relatively delicate and vital fore-and-aft control piloting is hardest.

An eddy will take an aeroplane in a variety of ways. There are instances on record of machines having been spun completely round by them. An attempt has been made, by a well-known military pilot, to classify remous as 'rollers,' 'half-rollers,' and 'wulliwas.' The 'roller' is the commonest form of bump experienced in an eddy. The machine tips up forward and then gives a corresponding plunge, or it dips downwards and then up, or it rolls with a list first to one side and then to the other. Whichever way the roll takes the machine depends upon which part of the machine first encounters the eddy. The eddy is probably a corkscrew arrangement affecting the whole of the machine in due course. Save in very aggravated cases the pilot may leave the righting process to the eddy.

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[1] G. H., April 1913.

The 'half roller' is either one or other of the above, but without the righting movement. A machine will be cocked head up and will remain in that position until the pilot corrects it, or head down or with a list to starboard or to port. These cases apparently are due to encountering the edge only of an eddy.

In addition, there is a peculiar effect experienced in thundery weather when the machine will quite suddenly oscillate rapidly sideways, the wing extremities moving rapidly and alternately up and down. This effect may be due to an eddy of a very small diameter, but vicious character. An aviator,[1] who has flown in Australia, has experienced similar conditions in clear weather, and he attributes them to the same movement of the air which, in the desert, produces the 'dust-devil,' or over water makes the water-spout.

Aeronauts are often able to see, when above the clouds, that the air is in great commotion. The surface of a cloud-field appears sometimes to be 'boiling.' A naval officer, flying at Eastchurch at a height of 8,000 feet, saw a vertical cone of cloud over 1,000 feet in height turning round and round corkscrew fashion.

The air is so sensitive that it is affected even by the colour of large patches of vegetation. Whether this be entirely due to the different heat-radiating power of different colours, it is impossible to say, but invariably an aeroplane on passing from grass land to a field covered with yellow flowers experiences a certain amount of air disturbance only less noticeable than the inevitable bump experienced in passing from green fields to ploughed or from ploughed land to meadow. A very interesting field of inquiry is suggested in this connection, and reference may be made to a theory that has been put forward concerning the supposed virtue of whiteness in the wings of an aeroplane. It is, of course, well known that the rays of the sun are repelled by black substances to an extent that anyone may see for himself by observing that familiar instrument, the radiometer, which is to be seen in the windows of most optician's shops. A writer in an American technical paper contended that this is good reason for covering aeroplanes with white fabric. He experimented with a small surface, black on one side and white on the other; this he supported in perfect balance, and when the black surface was exposed to the sun the contrivance became depressed. He also observed that dark objects placed on snow in sunshine sink, whereas white ones tend to protect the snow beneath them from melting, and he asks whether it is not a fact that the majority of the best flyers among the birds are not white-winged. The difference in the lifting qualities of black and white aeroplanes is probably too trivial to be considered, and the writer of the article claims far too much for his theory, inasmuch as he asserts that white-winged aeroplanes are proved to be the best flyers. It need only be pointed out that there are no black aeroplanes, and that almost without exception aeroplanes are covered with white, or nearly white, material. On the other hand, rooks and crows are black.

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[1] Lieut. H. E. Watkins.

One is reminded of the remarkable theory put forward by Dr. E. H. Hankin,[1] whose exhaustive observations of the soaring flight of birds in India form the subject of one of the most valuable contributions to the literature of bird flight, even though his theory be not universally accepted. Dr. Hankin came to the conclusion that the birds he observed soared best in certain conditions of the atmosphere, and that the quantity of sunlight had a great deal to do with the soarability of the air, and he found no reason to believe that birds only took advantage of upward currents, for they were observed to soar in regions where he could discover no evidence of upward currents. He assumed that air, under the influence of sunlight, contains a store of energy which, in some manner yet to be explained, is set free by the outstretched wings of certain birds. Since this force is outside scientific ken Dr. Hankin called it 'ergaer,' thereby possibly arousing more hostility to his theory than might otherwise have been the case.

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[1] *Flight*, August 12, 1911, to December 30, 1911.

That there is a definite field of inquiry in this direction is further shown by the theory put forward by Mr. H. T. Strong.[1] This theory is based upon the kinetic theory of gases and the movements of the particles or molecules of the gases of which the air is composed, or what is known as polarisation. The effect, according to this theory, is to obtain more support from the air than the mere density of the air is supposed to give. It is believed that a slightly concave surface like a bird's wing or aeroplane moving rapidly through the air induces polarisation in the air both under and over it. 'Although polarisation could only be a phenomenon of momentary duration, it may still be of sufficient importance to explain soaring flight; and thus the soaring flight of birds may constitute a demonstration on a grand scale of the kinetic theory, the source of the energy being the heat of the atmosphere; and it should be found that the air leaving the wing of a soaring bird is at a lower temperature than the surrounding air.'

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[1] *Aeronautics*, July 1913.

No apology need be given for making one more reference to the apparent effect of sunshine upon flying. Mr. G. M. Dyott relates some interesting experiences of flying in Central America.[1] He observed that the lifting power of his machine was very much less when flying in shadow, but he came to the conclusion that, when the sun is shining, there are rising air eddies which help the machine to rise. In the interval between the eddies the machine drops. The more eddies there are, and the more power they possess, the easier it is for altitude to be gained.

One more reference to air disturbances must here be made. It is to the backwash from other machines. This is of interest chiefly to aviators engaged in competitions in a crowded aerodrome. The backwash is met right behind another machine and just below its level. Sometimes it is only met quite close to the other machine, sometimes it is felt as far away as four or five hundred yards, the direction of the wind apparently having much to do with the distance to which it is carried. Its effect is a sharp oscillation of the machine from side to side, and the movement is corrected in the usual way. It is only dangerous when met close to the ground or if flying on a slow machine with only sufficient power and no margin for flying purposes.

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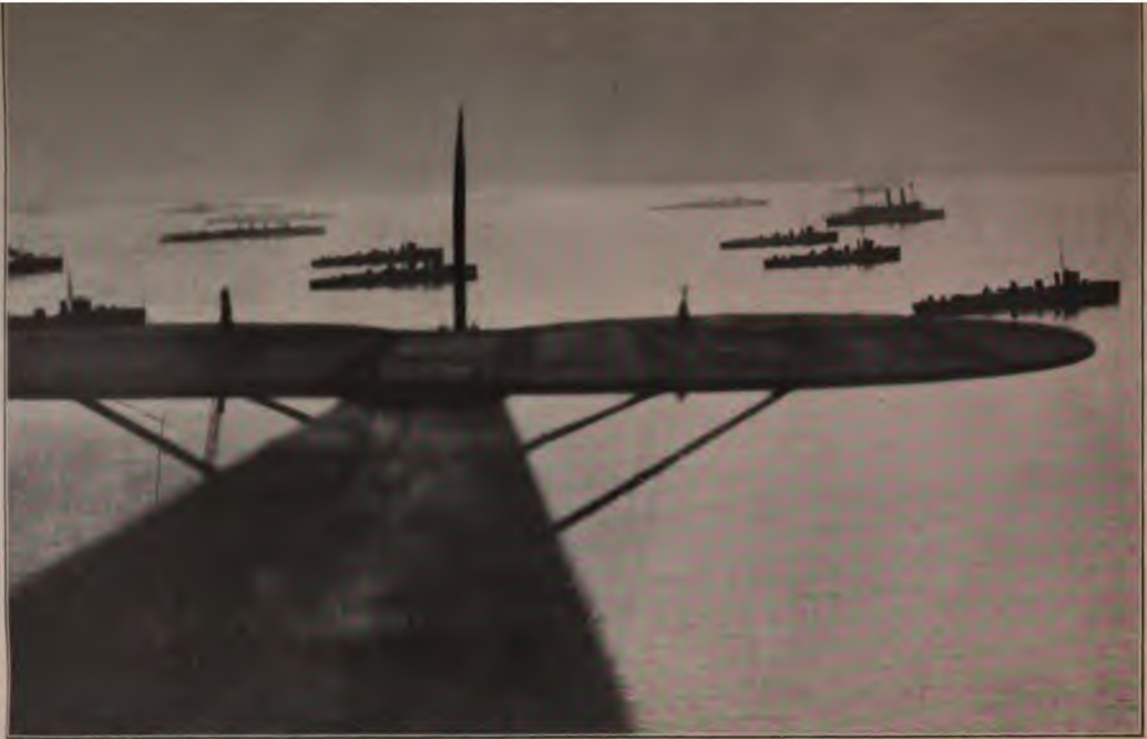
[1] *Flight*, January 18, 1913.

CHAPTER IX

WEATHER

Aeroplaning has not yet been brought to such a state of excellence that the pilot can safely ignore the conditions of the weather. The experienced flyer can, however, make an ascent in almost any wind and temperature. He is no longer prevented from flying by slight rain or snow. Thick fog and tempest are really the only conditions that make flying very dangerous. His weather outlook, however, is quite different from that of other people, and his acquaintance with the science of meteorology, although seldom expressed, soon becomes quite as close as that of the sailor. He rivals the fisherman and the farmer in the possession of weather lore, albeit he takes account of conditions to which they are indifferent.

Weather averages, to which so much importance is, no doubt rightly, paid by meteorologists, are of little interest to the aeronaut, any more than they are to the sailor. To the aeronaut the generalisation that March is a windy month means but little, he knows that he is just as likely to get good flying in March as in October or June. The fact is, average weather is seldom experienced, for averages are arrived at by striking the mean between extremes; foreign visitors to England have remarked upon the fact that our climate consists of extremes. For practical comment on the effect of weather upon flying, it is necessary



'Daily Mirror']

BATTLESHIPS AT WEYMOUTH

(From an Aeroplane, looking over the tail of the machine)

to turn to aviators or to those concerned with flying. For example, a Report of the Government Advisory Committee on Aeronautics states that for flying purposes as many hours are available in winter as in summer, and this in spite of the difference between the number of daylight hours in the two seasons. Gusty October, foggy November, and windy March are more than balanced by the bad weather frequently experienced in May, June, July, and August. This Report, however, was made some time ago, and the increased capability of aviators to fly in bad weather now gives the summer, with its many daylight hours, the advantage. All the biggest aeroplane tours and many duration records are now made in summer months, and, until the time comes when flying by night will be as easy as flying by day, aviators will do most work in the summer.

Practical flyers have found very little help from the work of the meteorologist, who, until quite lately, carried on his studies under the grave disability that he was never able personally to explore the atmosphere, and who, moreover, never worked with a view of the time when men would one day be able to roam at will in the air. When the art of ballooning was discovered it was promptly recognised that a powerful aid had come to the service of meteorological science, and in this and other countries organised series of scientific ascents were made, in many cases, with Government aid. The foundation was laid of the new science of meteorology. Of late years the work has been greatly facilitated by means of kites and unmanned balloons. The labours of Mr. W. H. Dines and Mr. C. J. P. Cave,[1] are of particular interest, for these scientists have carried on the work of sending up kites and balloons, with automatic recording instruments, on an extensive scale. These craft attain enormous altitudes and come down with data of which a great mass is now available for classification.

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[1] *The Structure of the Atmosphere in Clear Weather*, by C. J. P. Cave.

The science of meteorology is far from being exact. As Mr. W. H. Dines[1] has pointed out, it has never been satisfactorily settled whether it is a difference of barometric pressure between two places that create the wind, or whether it is the wind that gives rise to the different barometric readings. It is, however, established beyond doubt that the heating of the air by the sun's rays directly or indirectly is the primary cause of all wind.

The airman soon finds himself constantly observing the origin of winds, even though he be not at all a scientific person. He perhaps begins by seeking a reason for the eddies and the up and down currents he encounters, and from these it is but a short step to speculating on the cause of horizontal wind. Cold air descends and hot air ascends. The latter, as it reaches the region of reduced atmospheric pressure and is, therefore, enabled to expand, becomes cool in the process of expansion. The heavy cold air in descending becomes compressed, and like the air under compression during the pumping up of a bicycle tyre, becomes warm in the process. Mr. R. G. K. Lempfert gives a number of practical instances of this. He says: 'The Föhn wind of the Alpine Valleys is the most familiar. This is a strong wind which sweeps down the valleys from the mountain tops and passes, and is characterised by great warmth and dryness. Both dryness and high temperature are effects of the compression which the air experiences in consequence of its change of level. Temperature observations made at the top of the passes show that the air there is cold—

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[1] 'The Practical Application of Meteorology to Aeronautics.' *Aeronautical Journal*, January 1911.

clear evidence that the air gets warmed during its rush down the valley. Simultaneous observations made in the valley and on the pass during the occurrence of Föhn always show a difference of temperature at the rate which theory would lead us to expect, viz. 1° per 180 feet.'

It is a common mistake to suppose that air from above will be cold because it has come from a cold place. Unless it descends mixed with actual water particles it will certainly be warm, not cold. But warm air is capable of absorbing more water vapour than cold air, and if the warm air that ascends and becomes cool by expansion be laden with humidity it will, at a certain point, be forced to discharge its moisture in the form of rain or snow.

The study of meteorology is already part of the practical course of training at the Central Flying School, and observations of weather conditions for the guidance of navigators of aeroplanes and airships are now being made under Government authority. It stands to reason that in the equipment of the aerial navigators of the future, who will be so much superior in attainments to those of the present time, knowledge of all that comes under the head of weather science will be an important factor. It would, however, be unreasonable, in a book of this kind, to omit reference to the subject merely because the writers have not the necessary knowledge more than to suggest a few items for consideration.

According to meteorological science, wind does not blow from a place of high barometric pressure to the place of low pressure, but in a direction almost at right angles to a line adjoining the two points. The wind comes in almost from the side. The earth's revolution on its axis causes this effect, and the tendency to change varies with the latitude. Mr. W. H. Dines shows[1] that it may take less than eight hours for an unopposed east wind to become a south wind. It is important to remember that in the Northern Hemisphere, owing to the earth's rotation on its axis, winds have a tendency to turn to the right hand.

Mr. Dines urges aviators to become familiar with the weather charts issued by the Meteorological Office. In

Distance between isobars (in inches).	Gradient Velocity (in miles per hour).	—
0·1	223	The direction of motion may be taken as parallel to the isobars. In the Northern Hemisphere an observer, standing with his back to wind, has the region of lowest pressure on his left hand.
0·2	112	
0·3	74	
0·4	56	
0·5	45	
0·6	37	
0·7	32	
0·8	28	
0·9	25	
1·0	22	
1·1	20	
1·2	19	
1·3	17	
1·4	16	
1·5	15	
1·6	14	
1·7	13	
1·8	12½	
1·9	12	
2·0	11	
2·2	10	
2·5	9	
3·0	7	

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[1] *Scientific Journal*, January 1911.

these weather charts places of similar barometric pressure are joined together by lines called isobars, and the wind usually blows in a direction parallel to these lines. The distance on the chart between these lines is an indication of the variation of pressure over different regions. If the lines be close to each other, it is clear that the variation is great, and what is known as a steep gradient exists.

The table on p. 176 gives the gradient wind velocity in miles per hour, corresponding with the distances in inches and parts of an inch between the consecutive bars drawn on the working charts issued by the Meteorological Office every day, and it will be found that the velocity of the wind, at a height of from 1,000 to 4,000 feet agrees fairly well with this calculation. The isobars are drawn for each 0·1 inch. The table is calculated for a pressure of 30 inches; temperature 50° F.; latitude 52°.

To the aeronaut, the fact that the wind increases in strength with altitude is of immense importance. It is possible to show, by means of a table, the general amount of variation experienced. This amounts in Great Britain to an increase of about two miles per hour for every 1,000 feet. Greater variation, is, however, sometimes found, as the following table of the results of kite observations at Manchester on one day shows:

Height.		Velocity.	
Feet.	Metres.	Miles per Hour.	Km. per Hour.
1,100	335	21	34
2,000	610	24	38
3,000	915	46	74
4,000	1,220	54	89

Height.		Velocity.	
Feet.	Metres.	Miles per Hour.	Km. per Hour.
1,676	510	19	30
5,326	1,625	24	38
12,724	3,880	34	55
21,888	6,675	71	114
29,317	8,940	78	125

All these rules are affected by local conditions and by the direction of the wind. In anti-cyclonic conditions the rate of increase in strength with altitude is less, and sometimes does not even exist. In Great Britain this usually comes with an easterly wind.

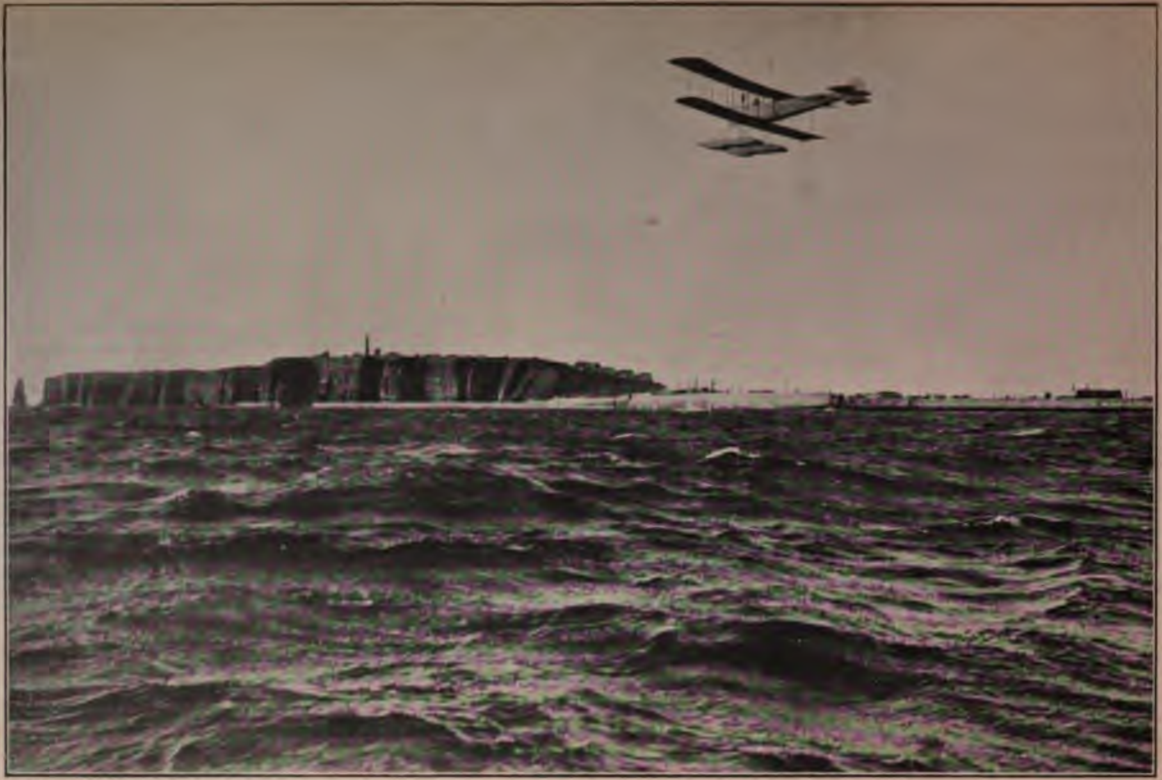
Taking an average of the surface winds throughout the year, Prof. Loomis found the following average velocities for the wind in various parts of the earth:

	Mean Velocity of Wind (Miles per hour).	Mean Velocity of Wind (Km. per hour).
Europe . .	10·3	16·6
United States .	9·5	15·3
Southern Asia .	6·5	10·5
West Indies .	6·2	9·9

It will be useful for the reader to have before him the scale of winds and their velocities now usually adopted:

BEAUFORT'S SCALE OF WIND FORCE

0 Calm	0–5	miles per hour
1 Light air . . .	6–10	,,
2 Light breeze . . .	11–15	,,
3 Gentle breeze . .	16–20	,,
4 Moderate breeze . .	21–25	,,
5 Fresh breeze . . .	26–30	,,
6 Strong breeze . .	31–36	,,
7 Moderate gale . .	37–44	,,
8 Fresh gale . . .	45–52	,,



'Sphere']

AVRO (BRITISH) SEAPLANE ARRIVING AT HELIGOLAND, SEPTEMBER 1913

The first machine of the German Naval Flight Squadron to fly from the mainland to the island.

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9	Strong gale	53–60	miles per hour	
10	Whole gale	61–69	,,	
11	Storm	70–80	,,	
12	Hurricane	80	,,	and over

From the following table the reader will be able to estimate the number of days in a year on which an aerial vessel of any given speed would be navigable. The table applies to Paris where the atmosphere is somewhat calmer than that of London.

Speed of the Wind in Kilometres per Hour.	Number of Days in one Year when there would be a possibility of Wind Velocity being less than that of the first column.
9	39
18	117
27	197
36	258
45	297
54	323
63	342
72	350
81	354
90	358
99	361
108	363
117	364
126	364
135	364
144	365
153	365
162	365

The condition of the air near the ground is greatly affected by the conformation of the ground. In open country and at sea it will be found that, at a height of 200 feet or so, the rules generally apply, but in country that is much diversified and broken up disturbing conditions are set up to a considerable height.

Even in so small a region as Great Britain contrasts are found in the weather of different districts. The eastern counties are relatively dry, and the western wet. An eccentricity of English weather, of interest not only to aeronauts but to farmers, has recently been discovered. This relates to the favourite localities for hail storms, which have been observed over and over again to cut a straight path through Huntingdonshire and Bedfordshire, and, in a less degree, through Lincoln, Norfolk, and Cambridgeshire, while neighbouring counties have been exempt. It is explained that hailstorms coming from the east do not fall till they touch the first bit of rising ground, and this rising ground quite empties them. There was a Huntingdonshire farmer, living on the side of one of the first hills west of the flat area of the Fens, who was said by his neighbours to have been 'hailed out of his marriage.' Whenever the date of the marriage was fixed the hail ruined his crops. He finally escaped by the simple plan of insuring: and the moral of this climatic peculiarity is that Huntingdonshire and Bedfordshire farmers ought to follow his example.

At the time of the London-Manchester aeroplane race, in 1910, the two competitors experienced air disturbances in the Leek Valley, in Staffordshire, which, owing to the trend of the hills, is a meeting place of the winds. At Lichfield it is said to be always blowing strongly, while in places only ten miles away there is calm. Aviators will learn to give certain localities a wide berth just as mariners avoid the Goodwins. There is a certain spot in the Himalayas where, during every hour of the twenty-four and throughout the 365 days in the year, the velocity of the wind never falls below sixty miles per hour.

With altitude not only does the strength of the wind vary, but also the direction. This was observed long since by balloonists, who very soon experienced a change of direction to the right as they ascended. John Wise, the aeronaut, said he nearly always found, at a height of about 15,000 feet, a strong westerly current. Observations of the drifting of clouds at different altitudes afford confirmation, but nothing very definite was established until systematic kite and unmanned balloon observations were organised. According to Berson the wind in 75 cases per 100 deviates to the following extent :

0	and	3,000	feet the	deviation to the	right is	15	degrees
3,000	,,	6,000	,,	,,	,,	13	,,
5,000	,,	10,000	,,	,,	,,	11	,,
10,000	,,	13,000	,,	,,	,,	1	,,
13,000	,,	16,000	,,	,,	,,	3	,,
16,000	,,	19,000	,,	,,	,,	6	,,
19,000	,,	22,000	,,	,,	,,	6	,,

a total twist of fifty-five degrees in about four miles ; so that, for example, a south wind on the ground becomes a south-west wind at a height of four miles. Under certain conditions of the weather, deviations from these figures naturally occur, and sometimes there is a twist in the opposite direction—*i.e.* to the left when ascending. In the Southern Hemisphere the deviation is in the opposite way. The general distribution of the wind is shown by the table constructed by Hann :

Geographical Latitude.	Wind on Surface of Earth.	In the Middle Strata, 10,000 to 32,000 Feet.	In the Upper Strata, above 32,000 Feet.
60° N.	W.S.W.	W.N.W.	W.S.W.
30° N.	N.E.	S.W.	W.S.W.
10° N.	E.N.E.	E.	E.S.E.
Equator			
10° S.	E.S.E.	E.	E.N.E.
30° S.	S.E.	N.W.	W.N.W.
60° S.	W.N.W.	W.S.W.	W.N.W.

As a rule it will be found that, standing on the ground, if you face the wind the direction of the wind above will come somewhat from your right. A south-east wind on the surface is fairly certain to turn to a south and then to a south-west wind at a moderate elevation.

One of the subjects upon which more detailed knowledge is very much needed by the airman is the local change in the direction of wind found in many places, and especially on the coasts.

It is of the utmost importance to aeronauts that they should take into reckoning these more or less constant variations in the speed and direction of the wind. The irregularity or the gustiness of wind is further important, since it affects the stability of the machine. The effect of an absolutely uniform wind would merely be to oppose, or to help, the speed of the aircraft. It would not be noticed by the pilot in flight, any more than a fly in the carriage of a railway-train would be conscious that the air in which it is supported is moving along at a velocity of fifty or sixty miles per hour. Illustrating the fact that wind, more particularly at high altitudes, is merely a body of calm air in motion, is the fact that the most delicately fashioned clouds retain their shape, as any one may see, although they may be travelling at the rate of an express train, and are made of a substance as light as air itself.

In the article by Mr. W. H. Dines, already mentioned, the author gives the following useful general data. The values refer to England but hardly differ from those obtained on the Continent. 'At the earth's surface the mean density of the air is such that one cubic foot of it will weigh one and a quarter ounces, but, owing to the changes in the temperature and in the height of the barometer, this value may be increased or decreased by some 10 per cent. The mean annual temperature in England is

MAILS BY AEROPLANE IN FRANCE

are.]

A 'TANDEM' BLÉRIOT MONOPLANE

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close to 50° F. At a height of one mile the density will be about 82—if we take 100 to represent it at sea level—and the temperature rather over the freezing point. At two miles the density is about 66 and the temperature about 20° F. At five miles, and this is about the limit that man has ever reached, the density has sunk to about 35 and the temperature to a value that will probably be between —20° and —60°. Up to five miles there is certain to be a steady decrease of temperature, but, somewhere between five miles and nine miles high, a point will be reached beyond which the temperature will cease to fall. The usual height of this point is seven miles, and the usual temperature is from −50° F. to −70° F.; but the temperature may be as high as −40° or as low as −90° F. At about fifteen miles our knowledge from direct observation ceases, but at this point the density is reduced about 3½ on the scale, and barely $\frac{1}{80}$th of the whole atmosphere remains above. The temperature probably is about −60° F.

‘At sea level in England the barometric pressure may easily vary from 29·00 to 30·50 ins. This is equivalent to a change of 1,500 feet in altitude.

‘At night, calm mostly prevails in the lower strata if the sky be clear; and this is particularly the case on frosty nights—and even days, too—in winter.’

Just as marine vessels, even the most powerful of them, have reason to dread not so much the effect of strong wind as that of the sudden violent squall, so the principal danger of wind to the airman is the squall. What in England is commonly known as the ‘Line squall’ usually comes from the north-west. These squalls are presaged by a sudden fall of temperature, a varying wind, a rise of barometric pressure and a shower of hail, rain, or snow. The squall is usually accompanied by thunder and lightning.

As airmen become more weather-hardy and defy the rain and the hail, it will be necessary for them to wear suitable protection. Flying in hail at a speed of fifty or sixty miles per hour is sufficiently embarrassing, but when, in the not distant future, ordinary aerial travel will be carried on at a speed of 100 miles per hour, hail and even rain would prove almost deadly. Pilot and passengers will, of course, be protected. It may be partly imagination, but it seems from many experiences that a cloud keeps its worst till the last. First soft gentle rain is encountered, or what would be soft gentle rain if the machine did not make a vicious storm of it by travelling at sixty miles per hour, then it grows denser and just the last edge of it is full of hailstones, and they are hailstones! They hurt. Those that fall down on the earth seem to be mere shadows of what they are like up in the factory where they are made.

The subject of regular air currents and the probable growing up of established routes, depending to some extent upon the seasonal and local direction of the wind, is a very wide one. The Zeppelin airship (No. 1) took advantage of the regular currents in the neighbourhood of the Rhine and the Swiss mountains, and by availing herself of these currents attained, on some occasions, a speed of seventy miles per hour. Thereupon attention was given officially to the air currents of Germany, and charts were drawn showing their seasonal variation. Wireless telegraphy has greatly helped work of this kind, and now that Zeppelin airships are equipped with wireless apparatus the work is going forward with great energy. To Great Britain the existence of regular air currents is a matter of more than academic interest, although they generally occur over great plains and over the ocean. Prof. Hergesell has spent many years investigating the air currents over the North Atlantic, the importance of which is apparent when one considers that aircraft move with the velocity of the current of the air in addition to their own independent speed. As Prof. Hergesell found that a trade wind blows from North-West Europe to the Florida coast at an average speed of twenty-seven miles per hour, an aeroplane or airship would be enormously helped by making use of it, for with an independent speed of only fifty miles per hour the combination gives seventy-seven miles per hour This current being found at a low altitude, conceivably the return journey would be made at a high altitude, say from ten to fifteen thousand feet where there is a constant flow towards the east at a speed of over forty miles per hour. By merely varying the altitude it is possible to travel in either direction and at a high speed. Practised balloonists, of course, have often availed themselves of regular currents and of directional variation. But all aircraft in the future will do so, since a helping wind means economy of time and fuel. Mr. A. J McKinney, in an article in the *Field*, points out that a similar phenomenon has long been noted in the famous Yosemite Valley in America, where air currents of a constant and decided character are found during the greater part of the year. Owing to its direction, the two sides of this valley do not receive the sunlight at the same time, the consequence being a marked difference in their temperature. This causes a strong up-current on the sunny side, which is especially noticeable in dry weather, as clouds of dust are drawn up with it. The strength of the current is, however, such as to lift the dust well above the heads of the wayfarers, and even above those of people seated on high vehicles. In the meanwhile the shady side of the valley is almost impassable by reason of the dense dust that creeps along it, a phenomenon taken advantage of by those who are familiar with the locality.

It has often been a matter for wonder that immense numbers of birds, many of them quite small, are able to cross the ocean every year with unerring accuracy. It was perfectly obvious to scientists and naturalists that the birds themselves were physically unable to make these enormous flights by their own unaided strength, and yet they were seldom found using ships as halting places. And on such infrequent occasions as they did so it was merely because they were driven a long way out of their course by sheer stress of weather, for, as soon as circumstances allowed, they took to wing again.

Investigations by Prof. Ernst Huebner, a well-known German naturalist, showed that migrating birds never cross the ocean except on storm currents. The little German redbreast, for example, which traverses the Baltic annually, never crosses except when there is a storm blowing in a favourable direction. This bears out experiences in other countries, as, for instance, Africa and America. The latter, by virtue of its immense distance from other continents, affords several striking examples of this phenomenon, as in the case of the golden plover. A remarkable statement was made in 1905 by Mr. W. W. Cooke, of the Biological Survey, to the effect that this bird, starting at Nova Scotia, flies straight away to the West Indies, a distance of 1,800 miles, and thence to Eastern America, another 600 miles. Occasionally the birds take refuge in bad weather on the Bermudas; but this is the exception rather than the rule, as they are frequently seen several hundred miles to one side of these isles.

CHAPTER X

DIFFERENT KINDS OF FLYING

THE future of flying unquestionably lies in practical cross-country work for military and general transport purposes rather than in aerodrome exhibitions; at the same time there exists a field for aviators specialising in other kinds of flying. The teacher of aviation confines his work to the school and does not, as a rule, become a very experienced cross-country pilot; the 'trick' flyer, in many cases, contents himself with exhibition flights; military and naval pilots develop along lines necessary to their calling; and the too small class of civilian tourist aviators fly solely for their own pleasure. Flying so suddenly became practicable that it took the world by surprise, and dangerous tendencies and customs have arisen which only the sad experience of repeated accidents will correct. It is highly probable that flying races in small closed circuits will always be held. They have some spectacular element, although, as scientific tests of speed, they leave much to be desired. In order to preserve the sanity of these contests it is necessary to impose certain limitations. Whether they be flown as 'scratch' races or as handicaps they are apt to put a premium upon the taking of undue risks. Skill in piloting, and particularly in turning corners, enters largely into the result, and although it may be argued that a pilot is his own master and that he has only himself to blame if, for the sake of a prize, he runs the risk of touching a pylon, it is unfortunately none the less true that the great majority of men fall in with established custom without troubling to submit the matter to their better judgment. Now, races in the aerodrome impose a very serious duty upon the organisers. There may be little danger in three good pilots flying round the course together, but clearly the danger is increased if there are four, five or six of them. The temptation to cut the corners rather too finely is very great in a good race, and flying being what it is, and mishaps being usually attended with serious damage to valuable machines and some risk of personal injury, it seems unwise to permit racing on precisely the same lines that it is carried on in terrestrial or marine craft. Those responsible for handicapping machines, again, have a heavy responsibility. Theoretical and scientific time allowances should be in strict accordance with the known speed of the machine. Unfortunately, handicappers invariably take into account also the skill of the pilot. Now, a skilful pilot, by doing fine corner work, will increase his handicap to the point when he can no longer compete with any chance of winning, but the temptation will be for him to try to do just a little better than he ever has done; in other words, he may be led on to the time when he fouls a pylon. It is easy to say that he is not compelled to race, but everyone knows how difficult it is for a man to have such command of himself that he can, under all circumstances, decline to take an unwise risk. Motor-car racing round the track can be extremely dangerous. Speed tests ought, theoretically, to be made by one machine at a time, but that, of course, would remove the spectacular element. On the whole,

'Flight']

MR. BEATTY ON WRIGHT BIPLANE

'Flight']

M. CHEVILLARD ON H. FARMAN BIPLANE

(Steeply banked at the Turn)

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cross-country races are to be preferred to races round the aerodrome.

Among the different classes of flyers the manufacturer's pilot belongs to one of the most important. Many of the greatest aviators have been associated professionally with particular firms of manufacturers. The work that they do calls for somewhat different qualities than are shown by the cross-country flyer pure and simple, or by the flight instructor, although either of the latter may be a manufacturer's man. It is the primary duty of the commercial pilot to preserve his life and limbs, and to avoid excess of all kinds, for accidents, no matter what the cause may be, involve a certain loss of reputation for the machine. Some of the larger manufacturers employ numerous pilots, each of them excellent in some particular branch of flying, as well as all-round men who are capable not only of breaking altitude records, but of doing 'trick' flying and also making long-duration flights. The qualities necessary for some of these divisions appear to exist only to the exclusion of the qualities necessary for the others, although for any one of them a man must be a good, sound pilot. Duration work requires long and steady apprenticeship. It was M. Georges Fourny, the maker of the duration record of thirteen hours, seventeen minutes, in September 1912, who, a year afterwards, built up the remarkable record of a daily flight of eight or nine hours for thirty consecutive days. This was soon exceeded by M. Hélen's thirty-nine days of flying, during which he covered over 13,000 miles. Flying of this kind needs particular application and training of a quite different character from that required for very high flying, and probably the temperament that made it possible for M. Fourny to achieve such extraordinary feats is quite different from the temperament found in a 'trick' flyer.

It has already been remarked that 'trick' flying, provided it be not carried on to such a length that it becomes merely a sensational spectacle, is indispensable to the progress of the art of flying. The 'trick' flying of to-day becomes the ordinary flying of to-morrow. Every aviator ought to note how so-called 'tricks' are done. Above all, he ought to know the limits of the capacity of his machine. An aerial manœuvre cannot justly be said to belong to the domain of 'trick' flying unless it absolutely lacks bearing upon practical flying. In the early days a spiral vol plané was regarded as a 'trick' but very soon it became part of the indispensable accomplishments of the cross-country flyer. Even the ability to fly upside-down is well worth demonstration, although few pilots will ever be called upon to go through the experience; but to fly upside-down merely to attract a big 'gate' to an aerodrome is not admirable.

In 'trick' flying, or, to use a better term, advanced flying, it is of supreme importance to keep always well within the power of the machine. 'Banking' should not be carried to the uttermost extremity. A dive should never be continued to a point so close to the ground that there is only just enough space in which to bring the machine level for landing. The pilot should always have something 'in hand'; he must never for one instant allow himself to continue a manœuvre of which he cannot clearly see the result, and at the first moment that the machine shows a tendency to 'take charge' his one consideration should be to get back to a safe attitude.

In advanced flying, where very decided turning movements are called for, the aviator must always use his controls gently. Violent manœuvres are extremely dangerous. For example, after a steep glide, levelling up the machine ready to land must be done by a gradual movement and not with a jerk. Hoxsey and two or three other American pilots owed their deaths entirely to attempting very sudden recovery to level flying after a steep glide. Suddenly to force a machine travelling at high speed into a new angle subjects it to strains of a severity that the manufacturer probably has not designed it for; indeed, to strains of which no one knows precisely the extent. No doubt, if we were only dealing with perfectly calm air, it would be possible to work out the precise effect of every possible manœuvre upon the structure of the machine, but the movements and inequalities in the air have not yet been accurately estimated, and it is against these that a very big margin for safety must be allowed. In a steep glide the machine attains a speed probably in excess of that commonly supposed. It is not uncommon to observe the speed of the propeller to go up to 1,200 revolutions per minute, due solely to the velocity of the machine when steeply gliding with the engine stopped. In all probability, to produce this effect a speed considerably greater than 120 miles per hour must be attained, and when that speed is exceeded the strain on certain parts of the machine passing through uneven air must be enormous.

After mastering the vol plané from any reasonable height, the aviator will begin to practise spiral descents without power. These are not difficult, and it is only necessary to keep sufficient 'way' on the machine by maintaining a steep enough downward path, and to observe caution in 'banking.' This work is progressive: the aviator gradually attains complete mastery of his machine and acquires experience in judging distance. He makes the spiral in smaller and smaller circles as he improves. In this, as in all kinds of flying, it is important to bear constantly in mind the direction of the wind, and if the engine be completely stopped the pilot must decide at once upon a landing-place and upon the direction to take the ground, alighting with a following or with a side wind being risky.

The true corkscrew descent was for long regarded as a useless 'trick,' but not only does it teach mastery of, and confidence in, the machine, it is a manœuvre that any cross-country aviator may be called upon suddenly to make. The first experiments were by one or two American flyers on the Wright biplane, but very soon pilots of other types of machine, both biplane and monoplane, mastered it. Not all machines are capable of a descent in small spirals, and aviators ought to proceed very cautiously when attempting this manœuvre on untried types. The Henry Farman biplane, up till 1914 at any rate, appeared able to do a better spiral than the contemporary Maurice Farman biplane. Many types of biplane promptly get out of control when brought to the attitude for a spiral descent. They begin to side-slip, and disaster is only averted when the machine is at so great a height that it has space in which to swing round into a normal position. The true spiral descent at first baffled monoplane pilots, and even when two of them[1] showed, in June 1912, that it could be done, they had only one or two imitators for considerably more than a year afterwards. They were flying at Anjou on that occasion, their machines being Blériot monoplanes driven by 50 h.p. Gnome motors. One of the pilots who soon followed suit was M. Gilbert. In a true corkscrew descent the machine is turned in a circle of no greater diameter than twice the machine's length. The manœuvre is executed in very much the same manner on all types,

[1] M. Garros and G. H.

but it may be worth while to explain here how it is done on a typical biplane and a typical monoplane.

Coming down spirally on his Henry Farman biplane M. Chevillard first pushes the lever over to the left and at the same time forward, thus bringing the right wing up steeply and putting the head of the machine down. The machine at once begins to dive down to the left, and the pilot levels the ailerons again and pulls the rudder to the left. The effect of this is actually to increase the 'bank.' Then almost instantly he pulls the elevator up. But the machine is now so much tilted up to the right that the elevator is no longer a horizontal plane; it is very nearly vertical, and elevator control becomes, virtually, rudder control. During these operations the engine is switched off; but, a true spiral descent having begun, M. Chevillard switches on again in order to have the machine in control for levelling out to land. These operations are made very quickly but smoothly, the pilot all the while feeling his control over the machine. When it is said that the elevator and rudder change functions, owing to the extreme cant of the machine, the meaning is that although both controls are performing their normal functions, the machine when tilted up on one side has an abnormal flight path. Turning to the left, for example, when the left wing is pointing almost directly downwards, is really turning earthwards; tilting the elevator upwards in this position has the effect of turning the machine to the left. To the beginner, who may have to deal with such a situation unexpectedly, it is most important to understand and remember that, in a great many machines, there is little chance of recovery from a real side-slip unless he is flying high. Now, the law of gravity being what it is, and unalterable, downward movements with the elevator are far more facile than upward ones, for the latter call upon engine power for their accomplishment, and can only be made, other things being equal, at the sacrifice of speed. In the same way, when the machine is careering about on its side, so that the rudder is playing the part of the elevator, the pilot will find it necessary to be very careful of his operations with the rudder: for, the lifting power of the machine being greatly reduced on account of its steep list, the slightest movement of the rudder giving an earthwards turn will have great effect. One thing the pilot must never forget: he must on no account attempt manœuvres calling for steep 'banking' unless his machine is well-engined. On an under-powered machine, which necessarily flies more or less tail-down, he dare not turn, unless he is at a good altitude, except in a very wide circle.

In his first attempts at a corkscrew descent the pilot should proceed very cautiously. The first essential to climb to a good height, and then practise steeply-banked downward turns through half circles, gradually increasing the 'banks' and the circles, and straightening out between each essay in order to think it over. One of the first sensations in a sharp spiral descent is giddiness, and it is against this that the beginner must guard. With practice the feeling of giddiness goes off, but only with practice. It is sufficiently accounted for by the attitude of the pilot, to whom the horizon then appears as an almost vertical line, and the landscape seems to be spinning round him. It is comparatively easy, however, to get accustomed even to this abnormal situation.

In a monoplane the first operation in a corkscrew descent is to dip the nose of the machine well down, at the same time turning it to the right or to the left,

'*Aeronautics*']

SPEED

Lieut. J. C. Porte on his Deperdussin Monoplane at Hendon

as the case may be. The same precautions are to be observed as in the case of the biplane, the pilot feeling his way down and round, and moving his controls in the manner required to effect the turn. He is constantly at work during the descent, especially if there be any wind blowing. With a machine well in hand it is possible to carry on the corkscrew until within a few yards of the earth and then to straighten out, but this requires practice and a sure eye. In the monoplane spirals now being described the pilot[1] keeps his motor in hand all the time by switching on and off. Moreover, with some power in addition to the force of gravity, shorter spirals are possible, and there is less slipping away to the outside of the circle.

The spiral descent is not a difficult manœuvre. In the first place, it is important for the airman to know that it can be done. Then it is likely to stand him in good stead on occasions when, over difficult country, his engine suddenly stops and he must make up his mind very quickly where to land. The best possible way of surveying the country within his reach is to go round in a spiral once, perhaps twice, for, by doing this, he rapidly takes into view the whole of the available area on all sides of him. For military purposes it will, obviously, in frequently arising circumstances, be a necessary operation; but there is no need to describe all the possible occasions for a corkscrew flight.

In the spring of 1913 Capt. Aubry, of the French army, flying a Deperdussin monoplane, was turned over by the wind and continued his flight for some 300 yards upside-down. Fortunately, he was at a good height, and was strapped in, and he retained his presence of mind. He brought the machine round again to the normal position and landed safely. Eighteen months previously Capt. H. R. Reynolds, flying a Bristol biplane, was turned over by the wind at a height of some 2,000 feet. He was not strapped in and was thrown from his seat against the bottom of the top plane. He managed to clamber back to his seat again, but the machine struck the ground before he could obtain control. He was uninjured.[1] In the summer of 1913, M. Adolphe Pégoud, a flyer of the Blériot monoplane, urged M. Louis Blériot to permit him to make a flight upside-down. He said he was sure it could be done, and that it was not a bit more dangerous than any other manœuvre. He contended, moreover, that the demonstration would have great value in convincing airmen all the world over that no position into which they could be thrown by gusts need cause them to despair, and that it was always possible on a good machine, if at a good height, to recover and land safely. As if to prove this contention, within a few weeks the aviator, M. Rost, when at the height of 15,000 feet, was turned over by a violent wind and lost control completely. He descended, turning over and over repeatedly, but never once lost his presence of mind, and was able to make a good landing. It is conceivable that the knowledge of M. Pégoud's experiments gave him confidence without which he would have lost his nerve and his life. For a long time M. Blériot declined to consider M. Pégoud's proposal. He said, 'Why go to this extent to prove what everybody knows?' But ultimately he thought out the necessary modifications to the machine to render it proof against the uncommon strains of upside-down flying. He took an ordinary standard type, a one-seater, strengthened the wings by slightly lengthening the cabane and so setting the supporting wires on the top side at a bigger, and therefore stronger, angle ; he also made the control more delicate, and put a larger tail on. A bent tube was attached to the vent in the cap at the top of the petrol tank in order to prevent too great an escape of petrol. It was intended that, while upside-down, the motor should be cut off, and it would not, therefore, require fuel. While in that position, by the way, petrol did escape through the vent tube to some small extent. Then, in order to prepare M. Pégoud for the experiment, this machine was slung upside down on trestles, and, by means of straps, the pilot was held in his place head downwards. This was to enable him to become perfectly familiar with the working of the controls while in an inverted position. Yeilding to persuasion M. Blériot then permitted a trial to be made in the air. This trial was observed by many eminent aeronauts and was quite successful. M. Pégoud flew to an elevation of 3,000 feet and then began to descend on a gentle curve. The gentle curve was soon changed into a very steep dive, and for about 500 feet the aeroplane came down vertically. Then it was seen to curve inwards, and for over 500 yards it travelled wheels above and the pilot's head pointing downwards. The pilot gradually brought the machine down vertically again, and from the vertical dive it slowly returned to the normal flight attitude and landed. The experiment was repeated, and very soon it had imitators in Mr. B. C. Hucks on a Blériot, M. Chanteloup on a Caudron biplane, M. Chevillard on a H. Farman biplane, Mr. Hamel on a Morane-Saulnier, and others. Meanwhile, M. Pégoud continued until he had successfully turned an upward somersault and also turned over sideways in the air. The latter manœuvre was found to be very difficult. M. Pégoud performed it in this manner : he permitted the machine to lose speed until it had become what is known as 'stalled,'—that momentary pause before the aeroplane turns over on its side or nose and falls—but while getting into that position he had warped the wings to the utmost possible extent, so that when it began to turn over sideways it came round to the upside-down position and then to the normal flight position again, diving to obtain the velocity necessary for the controls to have effect.

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[1] Flight by G. H.

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[1] See Chapter III. page 63.

Relating his experience M. Pégoud said: 'After four attempts to turn my aeroplane completely over sideways, though I forced it to an angle beyond the vertical with the earth, I could not drive it further. I am thus certain that it is impossible to capsize an aeroplane of deliberate purpose by pivoting it on its wing, because the machine is too stable. If, however, some fearful gust of wind should thus turn an aeroplane over, the pilot could regain the normal position by pivoting on the wing. I proved this three times by flying head downwards with the machine on its side, and righted each time, both on the right and on the left wing. Downward falls with the wings perpendicular to the earth, whether the engine is running or not, are no longer dangerous. I tried a whole series of such falls by warping the wing to its fullest extent without using the rudder. The way in which the machine righted itself, merely by a movement in the reverse direction, was simply amazing. For my falls of 500 feet tail downwards, I pointed the nose of the aeroplane upwards by pulling the control pillar right back and I "let her rip." The way I tried to capsize my machine sideways was by warping the wing to its fullest extent in the very act of "banking" steeply. If I want to capsize in the ordinary way I simply start coming down, stop the engine, and push the steering pillar right forward until the machine has turned over on its back. I have always wanted to "loop the loop," though I had not announced my intention of doing so. When I was 2,500 feet up, I began to precipitate descent by pushing forward the steering pillar. Then I pulled it backwards, the engine running freely until the machine was round the loop and ready for the vertical dive.'

Imitators of M. Pégoud—Mr. B. C. Hucks and others—used a petrol tank contrived to give a supply of fuel to the motor in any position. In this way the engine could be kept running upside-down, and in order to describe the complete vertical circle it was not necessary to plunge down vertically and gather enormous momentum. A fairly steep dive for a short distance with the engine running sufficed, and the additional elevator control provided on the special 'looping' machine, and the power of the engine did the rest. Mr. Hucks said soon after first looping the loop: 'Before you start turning over you have the same sensation as in a bath-room just before you get into a cold bath on a winter morning. When I made the machine dive I realised that I was going at great speed. The wind was terrifically violent against my face and roared in my ears. Once I got over on my back the sensation was one of delicious fascination. The recovery from the upside-down position was simply a repetition of the sensations of the mad rush downwards.

'In looping the loop when you start the turn you seem to sit still and the whole world revolves round you. The horizon disappears under your feet, and the next thing you see it coming back over your head. The whole thing is done so quickly that you don't know for the moment when you have finished. There was no unpleasant sensation except a rushing of blood to the eyes. I felt thoroughly self-possessed all the time.'

He had been in training for nearly a month, his exercises including being strapped upside-down in a chair.

But such a training, although an advisable precaution, especially in the early days of a new feat, is not indispensable. Nor is a specially-contrived machine essential. The loop was done on a standard 80 h.p. Morane-Saulnier,[1] and on the same machine the 'cartwheel turn'—turning to the upside-down position sideways—was performed.

The only change made in this machine was to reinforce the wings. The controls were unaltered. An onlooker described the first looping in this machine as follows:

'He climbed nearly to 5,000 feet, and even at this altitude his every movement was plainly discernible against the cloudless sky, and closely were these followed and anxiously, for he had expressed his firm determination to attempt the loop, a hazardous feat in his case by reason of the speed of his machine. Then suddenly he dived; the dive became perfectly vertical; the fall grew dizzily swift; abruptly the monoplane reared up, its nose pointed skyward, and there it remained, poised motionless, for a full second, then fell back and hurtled downward vertically a good 1,000 feet before the pilot recovered control and began to soar upward again. Mr. Hamel afterwards described to me his alarming sensations when, finding himself unable to complete the loop, his machine stopped dead in the air, and suddenly the rush of the wind died utterly away, and all motion ceased for a moment before that terrific dive ensued.

'But once again he rose to his former level, once again dived, reared up, and—this time with the motor full on—with a great effort turned the aeroplane right over on its

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[1] By G. H.

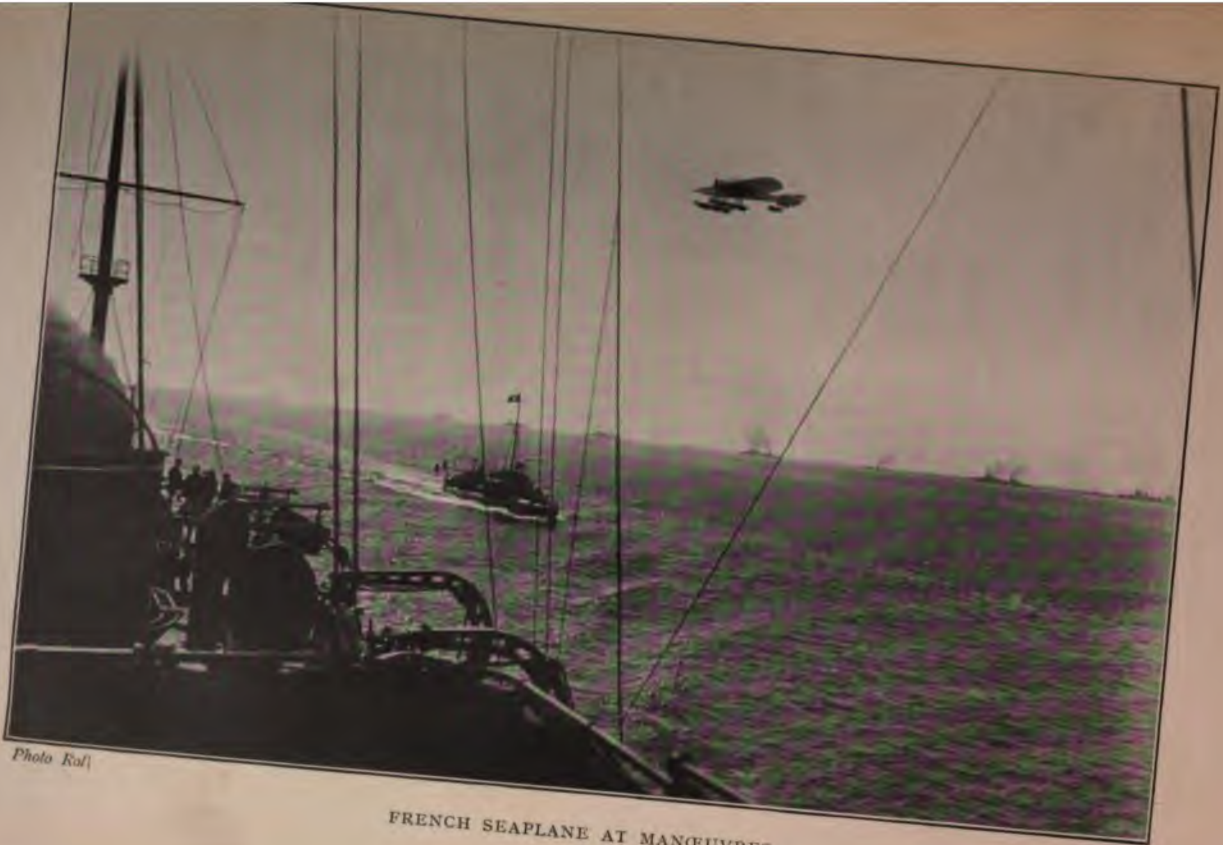

Photo Rol

FRENCH SEAPLANE AT MANŒUVRES

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back, and in this position remained for a few anxious moments, until the machine lurched, side-slipped, and plunged earthward. The loop had been accomplished. Once again the pilot regained control, and now gave an even more striking exhibition, for, coming down in a steep, narrow spiral, he uptilted the monoplane perfectly vertically on one wing, using his controls with might and main, as he told me later, in the endeavour to turn it over on its back. But the machine refused, and finally landed in a fine long glide.'

In order to be able to loop the loop successfully without the motor running at the top part of the circle one has to bring the machine down vertically about 200 feet, then pull her up not too abruptly, switch the motor on when in the horizontal position and keep it going till it stops of its own accord through want of petrol at the top part of the loop. It is best to pull the machine round quickly as otherwise she hesitates and stops. Once on her back the machine rights herself easily again by turning round and down on her nose. Then she can be steered right side up again from the vertical. The chief danger seems to be at the bottom of the dive in straightening out to commence the loop. This brings the machine suddenly from a descending speed of over 100 miles per hour to the level and then upwards, and the strain must be enormous. Therefore it is advisable to have the tanks so arranged that the motor is supplied with petrol all the time, thus obviating the need to bring the machine down at a tremendous speed.

Looping and upside-down flying promptly became part of the repertory of all the first-class pilots, their value for giving confidence in and mastery of the machine being generally recognised. Undoubtedly they did much towards showing the general public the principles of mechanical flight. His Majesty King George V, who from the days when flying became possible manifested keen interest in it—as, indeed, he does in every branch of science—expressed a wish to see this development of the art, and on February 2, 1914, an exhibition was given at Windsor Castle by an aviator[1] who looped the loop fourteen times on that occasion, observed by the King and Queen and other members of the Royal Family. Afterwards their Majesties conversed with the aviator for some time on the subject of flying.

Every aviator who does much flying finds himself constantly obtaining greater confidence in, and power over, the machine, and the progress of the art of flying has been marked by certain definite steps, some of which have already been described. The operation of landing has been greatly facilitated and improved by the skill of aviators. In the early days the only way of landing a machine appeared to be to come down on a gradual path with the engine either throttled down considerably or else ready to be switched off at the moment of contact. Then came the first vol plané. But very soon practised aviators found that they were able gradually to reduce the length of the run on the ground, which is not at all good for aeroplanes if the ground be rough, by what soon became known as 'pancaking.' This was done by allowing the machine to use up almost the last remnant of its velocity before actual contact with the earth. At the end of a vol plané the aviator would allow his machine to skim over the ground at a height of a few feet, the distance gradually diminishing until the machine, having lost way, would drop a few inches and stop almost dead. In rough country it is absolutely necessary to 'pancake' the machine, for running over the ground would otherwise wreck it. The high-speed machine is, for obvious reasons, more difficult to land than the slow one, and indeed the specialised racing type requires a large space of level grass, but increasing skill is showing that situations formerly regarded as hopeless may be saved. In order to reduce the run on the ground for a fast machine it was shown by a pilot of the Blériot monoplane[1] that it was possible, just before contact with the ground, to bring the tail of the machine down so that the main-wings presented a big angle against the air—themselves constituting an air-brake. The actual contact with the earth is made almost simultaneously by the tail skid and front wheels, but sometimes the skid is there in a fraction of a second before the wheels. This was possible, indeed easy, with the Blériot monoplane, but all machines are not so well adapted for the manœuvre. The Blériot normally flies at a comparatively big angle of incidence, and its tail is, relatively to the tails of that class of monoplane to which the Nieuport and the Morane-Saulnier belong, low down. It is only necessary to see a Blériot and a Nieuport in flight, and to observe how very tail-high the latter appears. Obviously, what is possible in one machine is not necessarily possible in another, and when it came to landing tail-down with a racing Nieuport or a Morane-Saulnier, difficulties appeared to present themselves. The Morane-Saulnier is what is known as a very fine glider, it descends without power on a very gradual path, and, of course, if the aviator descend steeply, the effect is merely to gather velocity and increase the speed at which the ground is encountered, or else render necessary a prolonged gentle glide, after the steep one, before the machine loses its speed. This peculiarity appeared to make it difficult, if not impossible, to land with the Morane-Saulnier in a tail-down attitude, the effect of such an attempt seeming likely to result in a broken machine. In normal circumstances an attempt to land a Morane-Saulnier, or any other machine, before it has lost way, results in a bad bump, a jump into the air, followed by a crash downwards. Clearly the fine gliders have certain limitations, one of their faults being that it is very difficult to land in a small area. But even with a Morane-Saulnier practice showed that it was possible to land almost as well as on the Blériot. On the latter machine, against a breeze of twenty-five miles per hour, it is possible to stop almost 'dead,' and if it be not possible to do quite so well with certain types of racing monoplanes, it is easy with many of them to stop in a fairly small space.

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[1] Flight at Windsor by G. H.

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[1] G. H.

Just as progress has been made by successive steps in the art of flying it is quite certain that progress is still to be made in the same manner, and manœuvres of which the airman of to-day has, perhaps, little idea will enter soon into daily practice.

Racing in an aeroplane is much the same as every other form of racing as far as questions of skill and judgment go. As regards the attainment of mere speed in an aerodrome it is best to fly close to the ground. The propeller grips the air better there, possibly because the air is cushioned by the pressure of the planes themselves and the air stream from the propeller meets the ground. There must, of course, be an almost complete absence of downward air movements close to the ground; rather, if any downward currents or eddies be in progress near the ground they would be deflected upwards and thus give additional lift.

Cross-country racing is purely a matter of machine speed and of making a true course without wasting time in climbing to unnecessary heights or in going out of the way.

Lieut. Conneau,[1] of the French Navy, wrote, after the big contests in which he took part in 1911—the Paris-Rome, the Circuit of Europe, and the Circuit of Britain :

'I gather up all my courage, then ; I spring into my monoplane ; I switch on the contact ; the propeller flies round dizzily ; I give the signal, metaphorically, to let go, and, with the map of Europe before my eyes, I rise into the air in search of my impressions, scattered over the route between Rome, Paris, Utrecht, Brussels, and London. For our impressions have wings, too, and I shall need all the speed and suppleness of my machine to grasp them in their flight.

'Here are three of them already on my road through the air, always the same, familiar to all airmen, varying in intensity according to the day, the weather, or one's state of mind—they are the anxiety at the start, the enthusiasm, and the ardour of the contest ; the manifold emotions of full flight ; and, finally, the immense joy, the involuntary cry of victory at the finish.

. . . . . .

'Houses look like dice thrown on a billiard table, the largest cities seem like Lilliputian towns, the bas-relief melts away, roads, rivers, and railways appear to wind their way in a child's model landscape toy. Only the sea and lofty mountains are spared in this wholesale diminution, and they always impose on the airman respectful admiration mixed with a very lively sentiment of fear.

'The airman mounts and mounts, his machine pointing upwards. Far beneath him the distant earth lies flattened out. Human sounds no longer reach his ear, deafened by the motor's roar. Suddenly, appalled by the utter sense of solitude, he rights his machine, and planes horizontally over hills and hollowed valleys. There are no more roads, nor bridges, nor barriers; forests, marshes, and lakes exist for the airman no more; the road is straight and clear in all directions, and on every side! It is then that man has the real sensation of flying, of having at last left the earth, of having conquered the air, as he has conquered the ocean, moving in it, playing in it, at his fancy, with a machine of his own invention, obedient to his slightest gesture, rising, falling, wheeling, and diving with the grace and lightness of the bird.

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[1] See *Daily Mail.*

'But in the great cross-country races man has yet another delight. He has not alone the sensation of fighting against air's treacherous element, but of striving in it against other men winged like himself, with a destination to reach like great migratory birds. The emotion caused by his victory over the air is heightened by the ardour of the strife to be the first to reach that little plot, as yet unknown to him, where, however, he knows other men await him, first with anxiety, then with astonishment, and lastly with enthusiasm at seeing two white, two human wings, at the hour appointed, braving the heavens for the first time.'

To the student of flying a vastly interesting amount of work remains to be done in the way of experiments, and since, for many years to come, this will be the case, the opinion of one of our greatest experimental flyers has been asked by the authors on the general question of the way to go to work. He writes as follows:

'My advice is that the prospective experimenter should confine himself to investigating something in which he has a better chance of obtaining results than anyone else. A general investigation into theoretical and practical aeroplaning is apt to become expensive and usually productive of no results. The rest is a question of time and money.

'The most important need at the present is an efficient wing of variable area.

'My own experiments are chiefly in the direction of instruments which will enable a pilot *to know* what his machine is actually doing in the air and in the reduction of horse-power required. This question of the advantage of instruments over sensation is likely to become more important in the future, because of the increasing protection from the weather given to pilots.

'As regard the angle of incidence, all the pilot can feel is his angle with regard to the horizontal. This, of course, has nothing to do with the angle of incidence of the wing, which is independent of the horizontality of the air[1] to the horizontality of the flight path.

'It is also impossible for a pilot to feel the rate of climbing of his machine, because, when once a steady rate of ascent is obtained, the pilot loses all climbing sensation and can only tell how fast he is going up by the look of the ground beneath and by the feel of the control of his machine, on neither of which can any reliance be placed, as they are dependent on the state of the pilot's liver and the exact output of the motor.'

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[1] 'Horizontality of the air'—By this is meant the direction of any air current ascending or descending on a slant.

Flying in the Services.

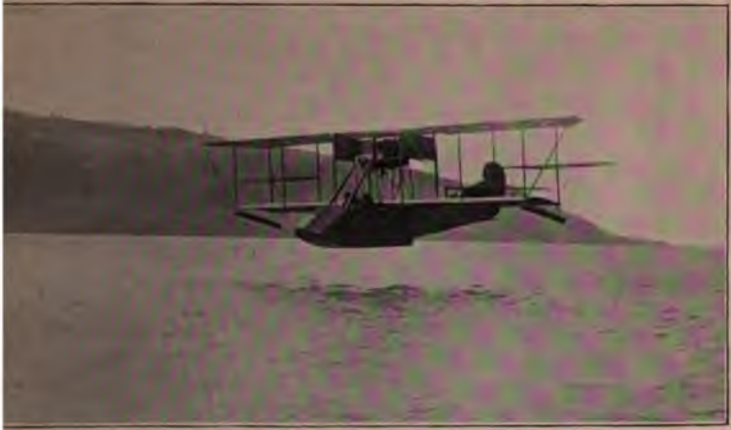
In the following article life in the Royal Flying Corps is described by an officer-aviator. The article deals with generalities and is designed to give the reader an idea of life in the Service. For details of Service conditions official reports may be referred to.

Chief among the blessings that prophets foretold would inevitably follow in the train of flight was universal peace. Some based their opinions on the fact that war would be made so appalling as to be impossible; others saw the world shrivelled to a hand's breadth and frontiers annihilated by the immense speed of aerial craft; others, again, saw in the facility of flying itself ample reason for the unarmed International arbitration, so popular among those who have never read history.

However, directly the aeroplane made its first spring over the soil, the world's War Departments began to interest themselves actively or negatively in the business, and at the present time it may be said that, but for its proved utility as an adjunct to existing fighting forces, this splendid science would have languished to the point of extinction from lack of public interest and capital.

In England progress was very slow. Military authorities were sceptical and disinclined to incur expense in the pursuit of a phantom advantage which might never materialise, and flying was kept alive by a handful of amateurs and a few army officers with means and enthusiastic convictions—as gallant a little band as ever took the air.

In 1912, the first move was made, the kiting and ballooning companies of the Royal Engineers became the Air Battalion and officially included aeroplanes—some Bristol and Henry Farman biplanes of what is commonly known as the 'box-kite' type, a Paulhan,



CURTISS HYDRO-AEROPLANE

ght]

. COMPTON PATERSON ON HIS HYDRO-AEROPLANE FLYING OVER TABLE BAY

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ASTOR, [illegible]
TILD[illegible]

a Bréguet, a Nieuport, a Deperdussin, and a couple of Blériots.

But the science was moving much too quickly for future development to be delayed, and early in the following year the Air Battalion ceased to exist, and the Royal Flying Corps was founded in its stead. The old Balloon Factory at Farnborough was reorganised into the Royal Aircraft Factory, and the Central Flying School for the training of both naval and military officers was established at Upavon on Salisbury Plain. At the present time officers of the Regular Army, having obtained the sanction of their Commanding Officers, and the Royal Aero Club aviator's certificate, pass through a thirteen weeks' course at Upavon and after an examination are, if they desire it and are otherwise satisfactory, posted to a squadron of the Flying Corps for four years, at the expiration of which they normally pass into the Flying Corps Reserve and rejoin their regiments. A certain number of civilians are also admitted to continuous service subject to qualification at the Flying School, being granted commissions in the Special Reserve of Officers, and serve for a period of four years, which may subsequently be extended with their own consent and the approval of the Army Council. Others, both Regular and Special Reserve Officers, go direct into the Royal Flying Corps Reserve after passing through the School where they are available for periodical 'refresher' courses and for employment in the event of war.

The establishment at Upavon has been called by a famous French aeroplane constructor 'the finest flying-school in the world.' It goes without saying that its staff is of the finest quality, and in all other respects it is singularly favoured. Its situation high up on the edge of Salisbury Plain is healthy and bracing, while the country surrounding it forms a vast natural aerodrome with just sufficient obstacles in the shape of hills, trees, and rivers to inspire pupils with a proper caution. Here the fledgeling attains to steady, level flight, generally running the gamut of all the various types of aeroplanes used in the Flying Corps. Keeping at first within a mile of the sheds, he is gradually permitted to go farther afield. Ludgershall, Bulford, and Larkhill—once prodigious adventures—give way to Salisbury, Hungerford, Swindon, and Devizes. The crown of school achievement is to travel to Farnborough, take delivery of a new machine from the Royal Aircraft Factory and fly it triumphantly home. It is a pleasant little run of forty-five to fifty miles. As far as Basingstoke the country is, perhaps, rather too wooded for a forced landing to be faced with complete equanimity, but onwards, over Whitchurch to Andover, one can pick up good landing ground after landing ground in unfailing succession; then comes the last dash over Sidbury Hill, and there lies 'Gallop Wood' with the sheds squatting greyly beyond.

But school life is not all flying. There are daily lectures to attend on all sorts of subjects connected with aviation, such as applied mechanics, theory of flight, strength of materials, internal combustion engines, practical navigation and map-reading, meteorology, types and formations of warships, formations and tactical dispositions of troops, elementary principles of gunnery, and so on.

Then also practical instruction is given in the care and assembling of engines and machines, and in signalling. At the end of the course an examination is held, and the successful candidate assumes himself to be the complete aviator—very nearly.

There is only one time in a pilot's life when he is quite conscious of omniscience in everything concerning flying, and that is when he has just taken his Royal Aero Club certificate. From that time onwards this consciousness grows gradually smaller, until after two years or so, having glimpsed the vast problems that lie ahead, he is generally willing to admit that he really knows very little.

The Royal Flying Corps (Military Wing) itself consists of Headquarters, Flying Depôt, and eight aeroplane squadrons. At the time of writing only five squadrons have been formed: Nos. 1 and 5 at Farnborough, Nos. 3 and 4 at Netheravon, and No. 2 at Montrose.

The general work in squadrons consists of reconnaissance, observation of artillery fire, and experimental work. Each squadron also has its repair workshops and motor transport to keep going. The experimental work is, of course, the most important item at present, and may be expected to remain so indefinitely. Therein lies the great fascination of aviation. All work connected with it is potentially creative; each mountain top scaled reveals 'range after range behind.' Again, it gathers nearly all the sciences into its net and makes them its servants. Military aviation of the future will call for the highest specialisation.

Turning from generalities to details, the Royal Flying Corps is the finest club in England even as the House of Commons used to be termed the finest club in London. It brings the officers and men into very close contact, inducing mutual confidence and trust and co-operation, which are the foundations of success. Also the Corps flies, not only because it is its duty to fly, but because it is its pleasure, because if it couldn't fly from some cause or other, it would get very gloomy and peevish indeed. It talks shop, too—always it talks shop,—and indulges in rude health and proper pride, discouraging 'stunting' and heroics. For the mere glamour of flying is passing, and the aviator is beginning to regard his machine simply as a convenient device for quick conveyance. When this point is fully established in the minds of everybody—pilots, press, public, and the powers that be—the true worship of the great god Efficiency has begun.

Flying is carried on in all kinds of weather, save in fog, which is the one condition regarded as 'impossible.' As to wind, only a big storm will keep machines in the sheds when anything is required to be done. In 1913 it was quite common to fly in winds of forty-five and fifty miles per hour. The officers commanding know just what can be done and what cannot be done. They do not ask for impossibilities. As to a man flying when he is out of condition that can only be his own fault. Illness is rare among those who fly, and a man has only himself to blame if, feeling unfit, he omit to consult the doctor and go on the sick list.

Such, then, is a general outline of the conditions now obtaining in the Military Wing of the Royal Flying Corps. How far its preparations and training go towards fitting it for war, only war itself can prove. Manœuvres and army exercises can teach it merely its A B C. It progresses—in the phrase of its official motto—'Per Ardua ad Astra,' but the Corps, as a subaltern therein remarked, 'likes its *ardua*.'

As to the Naval Wing, as already said, some of the early training is carried on at Upavon. Afterwards there is transference to Eastchurch, or any of the coast flying stations. In the Naval Wing there is, perhaps, a greater diversity of types of machine in use and a whole different division, namely that of the seaplane. Practically everything that has been said of the Military Wing applies also to the Naval Wing with, of course, the different Service conditions. A few civilians have been appointed but the usual entry is from the Service itself. An officer obtains his Royal Aero Club aviator's certificate, applies to join the Flying Corps, and if accepted goes to Upavon for the course of training.

CHAPTER XI

HIGH FLYING

ANY aviator who has flown to a height of 6,000 or 7,000 feet has demonstrated that he can fly to very much greater altitudes, for there is no essential difference in the demands upon his skill or his courage whether he flies at 6,000 or 16,000 feet. At the latter altitude, however, the question of the supply of oxygen sufficient to feed his lungs arises, and at 16,000 or 17,000 feet he should begin to inhale oxygen artificially as a precaution. There is no greater sense of altitude at 10,000 feet than at 1,000 feet; the sensation of dizziness does not occur to the aeronaut. No doubt, if he reflected upon the situation, an aviator, solitary in the great expanse, at a height of, say, three miles, might begin to feel extremely lonely, but that is about the only disturbing emotion to which he is subject, and is not very dreadful. The loneliness is, however, very real; the aviator is cut off most completely from his fellow men. In one flight[1] from France to England, the crossing being made at a height of about 10,000 feet, the coastguards, although on the look-out for the arrival, completely failed to see the machine.

What the aviator who ascends to great altitudes has to face is the strain upon his physique when flying in

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[1] Flight by G. H.

WINNING

A Borel Seaplane at the End of a Race

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air that is very attenuated, and the possible danger incurred in descending in a very brief space of time to the earth where there is a barometric pressure of some thirty inches. No matter how gently he takes this descent, he will almost inevitably feel its effects in temporary deafness. Coming down from about 10,000 feet in twelve minutes the authors have experienced a buzzing in the ears, and afterwards have had slight headache. These distress signals showing themselves, it is clear that the faculties have been to some extent impaired, and landing the machine, in which accurate judgment of the distance from the ground and delicate manipulation of the controls are necessary, should be done with care. This question is more fully dealt with in the first chapter, and in Dr. Adler's contribution at the end of the book, and it is clearly one to which the aviator who attempts high altitude work should give close attention.

The machine that is designed and engined particularly with a view to normal flying can quite readily ascend to heights of 10,000 or 12,000 feet, but beyond that, with engines of the present day, difficulties arise. In attempts upon the altitude record aviators have usually chosen a high-powered engine on a one-seater machine giving lifting power that would be excessive for ordinary purposes. The engine is specially treated to give the best results, not near the ground, but at some altitude above it. A machine on which you are 'all-out' at 1,000 feet is clearly not the machine upon which you can fly to 10,000 feet. This is partly a question of 'timing': it is necessary to prevent retardation when the supply of oxygen becomes less than normal. When a motor is retarded it gives little power and becomes overheated. The 80 h.p. Le Rhone motor on a Nieuport monoplane, with which M. Georges Legagneux flew to a height of over 20,000 feet, was so adjusted that it worked best at a height of about 6,000 feet. Flying near the ground it became overheated.

M. Legagneux, after creating the altitude record of 20,180 feet, on the 27th December 1913 said in an interview which appeared in *L'Auto* :

'The best means for training for flights for altitude is to fly high. Thus if I fly to Villacoublay or the neighbourhood, it is never at less than 3,000, 4,000 or 5,000 metres. If I go from Villacoublay to Chartres I pass over the 80 Km. which separate them rising continually. It is, besides, much more agreeable, especially when the weather is clear.

'When I set out from Fréjus to pass the 6,000 metres, I had one clear idea—to beat the record which was held by Perreyon with 5,880 metres; for it was necessary to exceed this figure by more than 150 metres, that is to say, to do at least 6,035 metres, in order that it might be passed by the F.A.I. On my barograph I marked a line at 6,150 metres. It was necessary that my needle should reach that point to succeed. I took on my machine a bottle of compressed oxygen.

'At the aerodrome the temperature was 12 degrees above zero (Centigrade). I rose, describing a circle above Antibes and l'Esterel. Here I noted a curious thing—when I was over the land the machine mounted well; above the sea it had much more difficulty in rising. Therefore contracting my circles, I no longer left l'Esterel.

'Another curious fact—and I am not the only one to have noticed it—was that over the Gulf of Antibes, the higher I rose, the more clearly could I distinguish the bottom of the sea. Many details remain fixed in my memory.

'I took twelve minutes to go from 4,000 to 5,000 metres; seventeen minutes to go from 5,000 to 6,000 metres. At 6,000 metres it was 22 degrees below zero—a difference of 34 degrees since the start.

'My barograph was covered with a layer of ice so thick that I could not distinguish the diagram; every second or two I rubbed it against me to see the movement of the needle. From time to time I used the oxygen; That saved me from the semi-torpor into which I fell again and again.

'When the 3,000 metres were reached for the first time by aeroplane, by the way, it was related that blood came from the nose, ears, and nails of the aviator. I confess that, happily, I did not feel any of these unpleasantnesses. But, instead, I felt as though my head were empty. I could no longer think of anything, even of the record to beat. But I wished to see the needle arrive at the mark I had put on my diagram. The motor "knocked" badly and made an infernal noise. The time seemed to me extraordinarily long,—at last, the needle reached 6,150 metres.

'Then I had only one thought, to free myself from this position, not exactly painful, but fatiguing. I had not the slightest wish to go 100 metres higher.

'The motor stopped completely as I descended. Twelve minutes later I touched the ground.

'I had used 60 litres of oxygen out of 600.'

When flying at a great height it is a struggle to keep a horizontal path, the angle of the machine having to be much greater in order that its lifting power may be sufficient in the thinner air. The machine climbs more slowly. The air becomes much colder, even on very hot days.

It has been supposed that, owing to the reduced air pressure at high altitudes, greater speed could be attained there than near the ground. Dr. Alexander Graham

Bell put forward the theory that the density of the air at a height of five miles being only one-third of the normal density at sea level, the speed of an aeroplane at a height of five miles would be tripled. 'At a height of 10,000 feet and more,' he said, 'there is always a general drift of air from America to Britain at a rate exceeding twenty-five miles an hour. This speed of twenty-five miles will enable a water-plane with a normal sea-level speed of forty miles an hour to travel in the rarefied atmosphere at 145 miles an hour. Starting from Halifax at daybreak, the airman ought to reach the coast of Ireland in time for late dinner.' But the law must not be overlooked that the lift of a plane varies as the square root of the density of the air, which means, other things being equal, that at a height of five miles (26,400 feet), where the air has one-third of sea-level density, an aeroplane of forty miles per hour normal speed would travel at about seventy miles per hour. It would, indeed, be compelled to do this in order to maintain horizontal flight. This, be it noted, is rather less than twice the normal speed, even at the tremendous height of five miles. But it is not in the least likely that airmen will be willing to make prolonged voyages at an altitude greatly exceeding the present height record. For one thing, until aerial navigation is an exact science, it would be impossible to find or to see the way at such a height. But, as we shall see, other considerations are opposed to Dr. Bell's theory, apart from the fact that his 'general drift of air' from the west is very often not found lower than 15,000 feet when, frequently, it is either north-west or south-west. In the latter case, on the Halifax-Ireland route, it would be abeam of the airman, and so far from helping him would rather diminish his speed.

There is really no evidence at all in support of this idea. Great difficulties are encountered. For example, that of oxygen for the man and the motor. Dr. Bell thinks that the greater speed would throw the airman against three times the ordinary amount of oxygen, thus creating for breathing purposes ordinary atmosphere. This is most unlikely. So far as practice goes, no aviator or balloonist nowadays who attempts to exceed a height of three miles (about 16,000 feet) travels without a supply of compressed oxygen. The propeller, meeting less resistance, would turn faster, but it would not be so efficient. The compression of the engine would not be so high. So that, to put the matter in a nutshell, it would be advisable to have engine and propeller specially designed for high altitude work, in which case they would not be so suitable for the lower altitudes.

In his lecture before the Aeronautical Society on December 6, 1910, Mr. W. H. Dines said:

'So far as aviation is concerned, we hardly need trouble about the conditions that prevail beyond a height of two miles. The lift that a flying machine moving at a definite speed can obtain is proportional to the density of the air, and the loss of one-third of the supporting power is somewhat serious, so that flying at a height of two miles is in some ways more difficult than at the surface. Still, the actual resistance to forward motion is less, and a greater lift can be obtained by a comparatively small increase of speed; and since the resistance is reduced, this can be obtained, provided that the engine is sufficiently flexible to develop the same horse-power and at the same time to run much faster. The decrease of density with height is not therefore so great an obstacle to obtaining great heights as one might suppose, and it admits of greater speed. The fall of temperature appears to be a more serious obstacle. The given temperature of

20° F., at a height of two miles is the mean for England; the actual temperature on any given date will depend on the season, whether summer or winter, and is also subject to large casual variations, just as it is at the ground level. Temperatures between 0° F. and 50° F. have been recorded by balloons at this height. The low temperatures increase the density and lessen the viscosity of the air, but these advantages are probably very small in comparison with the general inconvenience caused, and with the necessity for thick and therefore heavy clothing.

'Apart from the change of density with height, changes occur from the varying height of the barometer. At sea level in England the barometric pressure may easily vary from 29·00 to 30·50 inches. This is equivalent to a change of 1,500 feet in altitude. From the practical point of view it is not perhaps a very important amount, but it will undoubtedly be found easier to fly at times of high than at times of low barometer; also at times of high barometer the temperature does not decrease rapidly with height; indeed with a high barometer (anti-cyclonic conditions) the air is sometimes warmer at a height of one mile than on the surface. Also, too, in the event of an accident, there is a rather better chance of its not being so serious at such times, for the denser air checks the velocity of anything falling through it. In the caissons used for building the foundations of the piers of bridges and docks in deep water, where the air is greatly compressed, it is found that men may fall from considerable heights without injury, and did we chance to live on a planet where the density of the air was four or five times as great as it is on the earth, mechanical flight would be quite easy, though the speed of our express trains would be greatly reduced.'[1]

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[1] *Aeronautical Journal*, January 1911.

SIKORSKY BIPLANE FOR ELEVEN PASSENGERS AND PILOT

LEWIS GUN ON AN AEROPLANE

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CHAPTER XII

FLYING ON DIFFERENT TYPES

WHETHER in the future it will be an advantage to know how to pilot more than one type of machine cannot be foreseen, but there cannot be the slightest doubt that in the early years of flying an aviator's knowledge of different types could not be too extensive. In the first place, knowledge of different machines enabled him to make a wise choice, and in addition it improved aerial education generally. Even to-day aeroplanes are all experimental craft. A few brief notes on the different behaviour of widely differing types may have some practical value in this book, and, further, may be interesting to refer back to at some future time. No attempt will be made to cover the whole ground, and only a few typical varieties of machine will be given. And like other chapters, it is impossible to make this a kind of water-tight compartment. For example, the chapter on Learning to Fly contains a certain amount of matter which might reasonably have been included in this one. Nor can overlapping altogether be avoided.

The Blériot monoplane being one in very common use, and, moreover, being the head of a large family of monoplanes differing from it only in unimportant details, may reasonably be given first place. In flying the

Blériot, as in most machines, speed sufficient for flight is attained on the ground, and the ground is left, sufficient speed having been attained, without any action by the pilot. As a matter of fact, unless the control is used and the machine is elevated, it will probably be running along the ground a few seconds after speed for flight has been reached. This, however, does not greatly matter when there is a good surface and plenty of space. Indeed, it is far better than forcing a machine up in a tail-down position with insufficient power. To get out of a small field surrounded by hedges the elevator must, of course, be used, but it is idle to attempt this manœuvre unless there is plenty of reserve power.

The Blériot, and monoplanes resembling it, have not to be artificially banked in turning. When the rudder is turned to right or left the machine naturally takes up a suitable cant. Many pilots find it easier to turn in one direction than in the other. This, let it at once be understood, is not due to anything in the machine or the engine, but entirely to themselves. Generally speaking, all pilots find it easier to turn in the direction in which they first learned to turn. This remark applies to all machines. In making a gliding descent on a Blériot, and on any other tractor machine, when the engine is switched off the machine dips slightly forward, and will itself take up the proper gliding angle if left uncontrolled. It would, of course, be unwise to leave it entirely to itself, when flying at no great altitude, for irregularities in the air might cause it to slip down on one side to a certain extent before picking up its proper attitude. And if, at the moment of stopping the engine, the machine be slightly tail-down it is advisable to assist it in taking up the gliding position. When the wheels are within a few feet of the ground the machine must be levelled up, and it will travel forward, gradually sinking, until the wheels touch.

The Morane-Saulnier monoplane is controlled in very much the same way as the Blériot, and behaves in the same manner, with one or two interesting exceptions. The Morane-Saulnier does not take on a natural bank in turning; and it is necessary to steer and to warp the wings at the same time, otherwise the movements of the rudder will take very little effect. The Morane-Saulnier has what is known as a non-lifting tail, the Blériot has a lifting tail. The former, as a consequence, is much more sensitive to elevator control, and is rather more difficult to land, apart altogether from the respective merits of the different landing carriages. As explained elsewhere, it is easy to land with the Blériot, bringing the tail down at the finish so that the wings act as an airbrake and the back skid touches earth in a fraction of time before the wheels. This further helps braking, and the machine can be stopped in an extremely small space. It is more difficult, though quite possible, to do this with the Morane-Saulnier. Taking the two-seaters, the Morane-Saulnier of 1913 was more delicate of control than the Blériot of the same period, the passenger being seated close behind the pilot; whereas in the Blériot the passenger was seated two or three feet behind him, the effect of his weight upon the attitude of the machine being marked. From this point of view, at any rate, the Morane-Saulnier had an advantage. In later Blériots passenger and pilot were closer together.

It is often supposed that machines with a very small span, and especially those fitted with racing wings, are more easily upset by gusts than are others. With properly designed wings this is not the case. It is extremely difficult, no matter what efforts are made by the pilot, to upset a Blériot monoplane. To perform an overturning movement in the air M. Pégoud and other trick flyers had very large elevators to their machines, and the wing warping was also increased, the control being geared up. If a Blériot or any other well-designed monoplane gets 'stalled' in the air, that is to say, with her tail down and no forward speed, she slips down on one side or the other, then her head comes round and down so that she takes on a steep gliding angle, attaining forward speed which renders her easily controllable. This fact cannot be too deeply impressed on the minds of young pilots, who may gather confidence from the knowledge that, provided they maintain a reasonable altitude, no danger can befall them in the air.

The following notes on flying different machines were made by the late Lieut. Wilfred Parke, R.N., and published soon after his death in *The Aeroplane* and in *Flight*:

NOTES ON CODY'S 'CIRCUIT' BIPLANE

(*September* 30, 1912)

'I flew this in November, 1911, then fitted with a Green engine (60–80 auxiliary ports). It is a delightful machine to pilot, and easy, the control, though unconventional, being very suitable for the machine. The great point about the control is that the column is continued above the wheel and grasped with the left hand, which does all the balancing, the right hand being placed on the wheel only when required to steer, the warp and rudder being interconnected with the warp very low geared, and rudder balanced and high geared; the amount of power required from the pilot is small. On the other hand, the gear between rudder and wheel is very low, making the machine a little awkward to steer on the ground, as it takes some appreciable time to get the rudder over.

'One disadvantage of using so much rudder to preserve lateral balance is that, if you try and land using the engine, the movement of the control to correct for torque may have rather a disturbing effect on "direction," which is a nuisance near the ground; it is easier to land *en vol plané.* Though easy to control, she wants just watching all the time for lateral balance, probably due to the inverted dihedral; you keep on just slightly working all the time, but very slight; fore and aft she more or less looks after herself.

'When I smashed her I had a big load up, turned down wind whilst forcing her to climb; she lost speed, started to rock, and finally side-slipped when about thirty feet up; directly she side-slipped her big rudder area put her nose down, and I started to pull her up with the elevator; another fifteen feet and the smash could have been saved, as she was starting to answer quickly: unfortunately, the small front wheels actually hit in a ditch and brought her up all standing, with considerable damage; I was shot out head over heels, quite unhurt, as my helmet showed marks of having saved me from some nasty cuts by wires; my passenger was more or less jammed in his seat and also unhurt. I had previously flown this machine solo from Farnborough to Brooklands and back, landing at Brooklands, and made a vol plané with engine completely stopped from over 2,000 feet. Note that the elevator was almost dead balanced in normal flight; if going faster (as *vol piqué*) it pushed the control back, and if climbing her too much pulled the control forward; I don't think the elevator carried much load with the Green, and doubt that it does with the Austro-Daimler.'

HANDLEY PAGE MONOPLANE

(*October* 20, 1912)

'For a start, there is no doubt that this 'bus is of a really fine and extremely promising design; whilst not quite so efficient as, say, an Avro (W.O. type), it does not do at all badly; it flies at, so far as I can judge, just under 55 m.p.h. with a probably unsuitable propeller (Blériot Chauvière Circuit de l'Est type). Extra weight makes practically no difference; indeed she gave no sign of being overloaded with two kids, totalling sixteen stones, in the passenger seat; she is certainly a bit slow at getting off the ground, and I do not make her climb fast, but the latter has probably got something to do with me, as her ordinary gentle rocking motion probably makes me think I have got her *cabré* when really she is going up perfectly all right—*i.e.* she could climb faster if she were made to.

'Now, as regards her inherent stability, her lateral stability is as near perfect as I can imagine; she just simply floats about quietly, quite regardless of remous, propeller draughts, etc.; you can feel them hit her, and her consequent "automaticing," but it does not worry her at all. As regards banking, she takes up her own angle quite naturally; she appears to be moving on an approximately uniform path after turning the first 135 degrees (about), and for trial purposes I have frequently extended the turns to over 360 degrees, this makes no difference whatever to her; she simply continues as sweetly as possible, everything remaining unchanged, including the pressure on the rudder, which, though very light (a possibility of observer's error, therefore), appears to always remain on the inside—*i.e.* when turning to the *left* with uniform angularity, the pressure is always

AVRO SEAPLANE

AVRO SEAPLANE, ANOTHER VIEW

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on the *left* foot, though the force is less than whilst accelerating.

'To bring her off a turn I used, at first, to use the warp at the same time as I ruddered, but have since found this unnecessary, as she comes up quick of her own accord. For trial purposes I have reversed the rudder from half-left to half-right and watched her swing over and pick up her bank on the reversed curve without needing a touch of the warp. With reference to this, it is interesting to note that, after straightening out after a sharp turn, she will " hunt " laterally for a short time to pick up her normal lateral attitude. I noticed this particularly once when shutting off to vol plané rather low from a sharp turn, when this hunting gave me quite a lot of work to do with the warp to make her take the ground on an even keel; it probably would not matter a bit touching one wheel a good deal first (with the excellent type of under-carriage fitted), but looks bad. Natural control—she has any amount of it, though the warping wheel is rather low-geared to my mind: she is quite reasonably quick on the warp. Longitudinal stability—I have so far been unable to determine accurately whether there is any serious improvement here over other decently designed machines on standard lines; longitudinal control is usually so easy that one would not notice this much; it should be tested by having some means of holding the elevator control fixed, which is not possible by hand alone. I think she must have something subtle in her longitudinal arrangement, as, in spite of the passenger's seat being right back in rear, the difference between sixteen stones and six stones makes no appreciable difference to balance or control in the air.

'She answers her elevator well, but gives the impression of having that control rather low-geared too; possibly that impression is helped by somewhat increased moment of inertia due to passenger's position; anyway, I very noticeably use more motion of the control column to land than I am accustomed to do on other machines.

'She has a very good gliding angle, about the same as the Avro (say 1 in 6·5), and is consequently very easy to land in an aerodrome, particularly as her undercarriage is very "squashy" and with no tendency to bounce. I believe its springs are worn out. She runs rather a long way, as the tail skid keeps her tail rather high.

'Her rudder has a good aspect ratio, and though unbalanced, its control is very light; I only rest my toes on the bar. The seating accommodation is excellent, far better than is usually found; both pilot and passenger get excellent protection from the wind except just their heads.

'In conclusion, she really flies, and for pure pleasure of flying it is miles ahead of anything else I have ever been in as pilot or passenger. She is, to my mind, an extremely safe and excellent machine.'

CAUDRON BIPLANE: 35 H.P. ANZANI

'My experience of this machine up to date has been gained on the machine belonging to Percival (Aero Construction Co.). I flew her for some trial flights, and then in a couple of small races at Brooklands, one cross-country and the other round pylons (this was the only pylon race I have ever flown in; I do not care much about them, thinking them unnecessarily dangerous owing to the danger of machines passing each other rather close when rounding a pylon).

'What has chiefly impressed me about this little machine is its extreme steadiness in the air, especially when considered in relation to its small span and light weight. It appeared to have quite a high degree of inherent stability, probably due to its flexible surfaces, though actually I did not test this systematically, being at that time too fond of correcting the smallest deviations. The machine is rather heavy on its lateral and longitudinal controls, and would, in my opinion, be very much improved by the substitution of a wheel control for the standard universal lever. It is a very easy machine to fly on account of its steadiness and ample control, which it answers very well. For pupils, I am inclined to think that the rather heavy controls are an advantage rather than otherwise.

'One thing I noticed was that I tended to land much more "tail-high" than usual, from which I deduce that she has not got a very good gliding angle. Also one has the impression that one is coming down much more steeply (*en vol plané*) than one really is. Left alone when turning sharply, she takes up a very nice bank, but I have no reason to fear her overbanking herself; in turning sharply either way she has a strong tendency to dive, which can be resisted by the elevator; I attribute this to her sharp bank making the rudder act partly to raise her tail, especially as the pressure remains fairly high on the *inside* of the rudder. At any rate, this up to 180 degrees turns; more than that I did not try. There was a good deal of vibration from the engine, rendering the Gnome-type oil indicator useless; and that, in conjunction with the rough seating accommodation and moderate weather protection, render her less luxurious to fly in than many machines.

'Still, considering her very low price, I think she is perfectly marvellous; her proper duty no doubt is the school, for which she is admirable; but she is also splendid for the private owner of very limited means, as I should have no hesitation in using her for any amount of cross-country work; she has a very good margin of lift, and rises quite fairly quickly and stops well. Her "Y" Anzani engine has a very good reputation, and only requires proper intelligence to look after. I know from close touch with the Deperdussin people when Sabelli was with them that once the "Y" Anzani is given enough oil it is very reliable and wants little attention.'

DEPERDUSSIN MONOPLANE: 70-H.P. GNOME

(*October* 26, 1912)

'A few days ago, through the very great kindness of Lieut. Grey, I had a short (very short) flight on his (Service) machine of the above type. I only did a single circuit, having to come down, as the engine was not running properly.

'She struck me as being a very easy machine to handle; but the view from the pilot's seat, as for landing, might be a good deal better; having a very good length of machine in front of the pilot, it is certainly a help to the pilot. What I noticed particularly was that I was pushing very hard on the control wheel, *i.e.* carrying a big load on the elevator flap, though this may be partly due to the fact that I was purposely keeping her from climbing; also that in spite of its being almost a calm, I could feel the wheel kicking at me quite strongly, *i.e.* automatic warp: owing to having a big weight on the tail skid, she does not steer over well on the ground, though obviously the pilot can soon, with practice, overcome this.

'My flight was too short to test for inherent stability, etc., though from the way she handled I should expect to find she had a certain amount, though probably very lively and terrifying at first if left alone. She is very light on her rudder and answers it well. With the scuttle dash now fitted the pilot is quite reasonably comfortable, but passenger flights have shown me that, though the passenger can see very well, his accommodation is the very worst I have ever experienced; he gets his head blown off and his lower part is in a "cave of winds."'

HANDLEY PAGE MONOPLANE: 70-H.P. GNOME

(*November* 15, 1912)

'I had this machine out for the first time last Saturday, *i.e.* she was flown a little at the trials by "Petre the Painter," but has since been reconstructed and with different wings.

'She is extremely interesting compared with the "50" machine; longitudinally she is dead stable, *i.e.* I held the elevator control, as far as I could tell, rigid, and she never varied a bit; the "50" is good, but not quite so good as this. Laterally, she rolls in a most unpleasant way, and banks to an absolutely appalling angle if left alone. I did not let it alone after the first time: though rolling heavily she recovers herself perfectly without any use of the warp; she appears to have a very regular periodicity, which I hope to time next time. She lacks the v.g. [very good] directional stability of the "50," *i.e.* on a roll she requires a little rudder to prevent her swinging to the low side. This use of the rudder is distinct from the use I very often make of it, to stabilise a machine by sharp little pushes. In turning, as soon as she approached a uniform curvature, one continues to turn with a negative pressure on the rudder, *i.e.* on the outside thereof. I had not previously experienced this even on the all-enclosed Avro, though I am told several types have it, notably Ogilvie Wright's and the B.E. 2.'

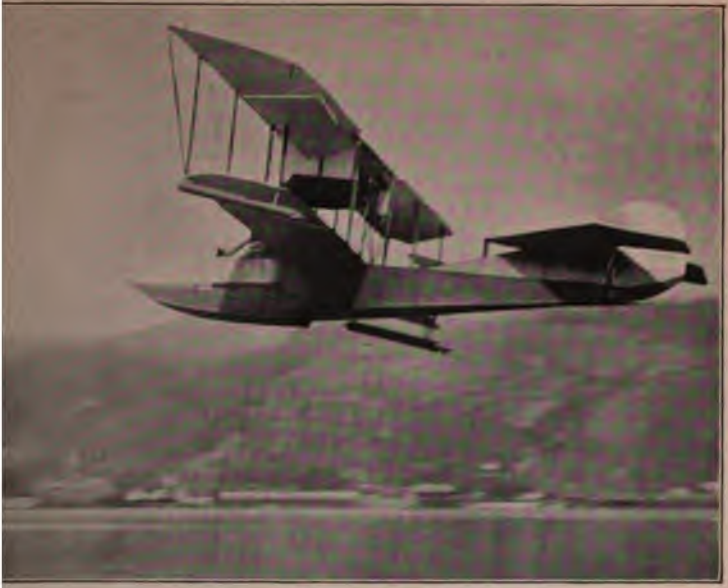
CHAPTER XIII

OVERSEA FLYING AND THE HYDRO-AEROPLANE

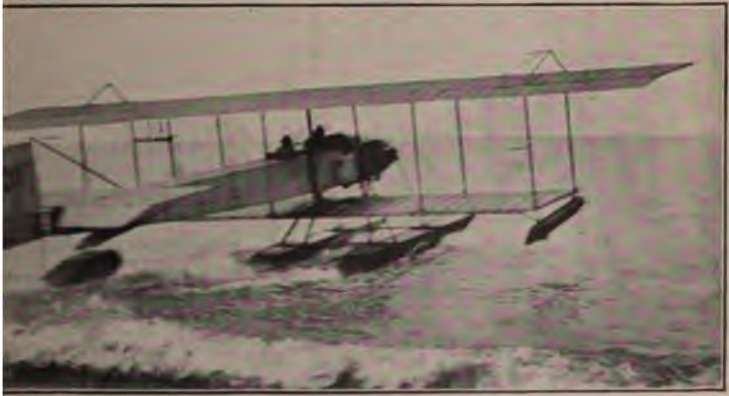
THE hydro-aeroplane is not yet a machine upon which any reliance can be placed even in favourable circumstances: the problem of the sea-flyer that will, with some measure of certainty, sustain a descent upon rough water, ascend at will from waves measuring five feet from crest to hollow, and at the same time be able to fly with reasonable efficiency, is not yet solved.

It has been assumed by many that the hydro-aeroplane is less frail and less dangerous than the ordinary flying machine, that it is peculiarly suited to the genius both in mechanics and navigation of the British nation, and that Great Britain is leading the way in its development. Now, even if it be true that Britain has secured a lead in hydro-aeroplane development, it would mean little in actual achievement, so primitive are all hydro-aeroplanes so far produced.

It is highly probable that all the sea-flyers tried in public hitherto are doomed to extinction. Long flights have been made; a few have crossed the Channel and longer stretches of water; a few—British as well as foreign sea-flyers—have outlived some buffeting in choppy water; but not one machine has yet undergone a sea voyage in moderately rough weather with frequent ascents and descents, and it is doubtful whether any



CURTISS SEAPLANE FLYING OVER LAKE KEUKA



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existing sea-flyer could sustain this very practical ordeal. Big isolated performances are, of course, at any time possible, but too much must not be inferred from them.

The problem of the 'landing' carriage is far more difficult to solve than in the case of overland flying machines. Quite erroneous is the common idea that the shock of a descent upon water is less than that of an ordinary landing: on the contrary, the slightest unevenness in the surface of the water is apt to smash a float and even buckle the chassis. Except on smooth rivers and land-locked bays the descent is much rougher than on land. Water if struck with any violence is in effect as hard as concrete, and the sea, with a moderate swell or with the smallest of 'choppiness,' is, from the point of view of the aviator, 'like granite agitated by an earthquake.'

Nor are the dangers of hydro-aeroplaning less than those of overland flying: in a big fall the damage is just as great, and there is some danger also of being held under water if the machine is submerged or overturned.

One other point: it is necessary to bear in mind that no aircraft in which astronomical bearings are not taken, or that is likely to fail through engine trouble and cannot stand a few minutes of buffeting by waves, ought to venture out of sight of land or of ships. In this respect the hydro-aeroplane, as it is to-day, is no better than the ordinary flying machine: it is fairly efficient for use in and over calm water, but the conditions in which it could be used with comparative safety are rare; and, indeed, are more rare round the coasts of Britain than in more equable climes. All these problems will be solved in time. The efficient sea-plane is certain to be evolved. Meanwhile, no nation possesses it. In any war likely to break out between maritime Powers, the ordinary land flyer will be used in operations in conjunction with the fleets at no great distance from land. But it will be so desirable to have the assistance of air scouts in operations at sea that even in the present state of affairs some way out of the difficulty will be found. This way may not at first be by means of hydro-aeroplanes, at any rate to more than an experimental extent (and it is extremely doubtful whether any naval commander will trouble himself about craft upon which he cannot rely). Possibly battleships will take out to sea small monoplanes with a stock of spare wings and other parts, all of which could readily be stored in small compass. Such craft would take flight from the deck, but upon returning from their work they would have to alight upon the water. This would involve frequent breakages as would also the operation of hauling them on board again. The machines, therefore, would have to have readily replaceable parts. Spare engines would, of course, be included, for the troubles of the aero-engine at sea are greater than overland. Indeed one of the serious problems of the sea-flyer is the engine; the troubles of good water-cooled engines in motor launches are bad enough, how much more serious is the position of the light air-cooled engine in an aeroplane where it cannot receive the constant personal attention of the pilot, and is likely to be splashed and drenched, and consequently often warped, at every descent. The 'deck-plane' described in Chapter XV may form another solution.

Unanswered are many of the questions concerning the general design of hydro-aeroplanes, and beyond a general belief that all existing float contrivances are unsatisfactory and that a real air-boat must be developed, no one is able to foretell what will be done. When fairly equal distribution of loading is secured, it is usually at the expense of airworthiness, due to the arrangement of parts giving air-resistance at the wrong points. It is even more important for the pilot of the sea-flyer to have a good view than for the overland pilot, for the very slightest misjudging of the distance and the condition of the surface of the water may lead to bad trouble. For this reason not one of the monoplanes provided with floats, on which big flights have been made under conditions, be it said, that did not require them to make frequent descents on troubled water, can be regarded as an established type of hydro-aeroplane. The problem of giving the seaplane—which necessarily offers big resistance to the wind and obviously cannot be provided with heavy ballast—the quality of floating stability enabling it to keep a fairly level keel on the water and to avoid being quickly wrecked has by no means been solved. Possibly the future will lie with the boat rather than the float type.

But to come to details, the engine difficulty is one of the most serious, and one of the reasons for the relatively slow progress made with hydro-aeroplanes is the fact that the air-cooled engine is most unsuitable, the rotary type of engine, therefore, being ruled out. The reason for this is that of the necessity to protect the motor from splashing by water and the sudden cooling caused thereby. This interferes with the regular working of the engine. In the case of the Gnome rotary motor salt is drawn into the crank chamber with the air and thence is taken into the cylinders, causing them to overheat. The seaplane motor ought to have the ordinary induction pipe. An air-cooled engine, of course, must not be covered. It is particularly necessary to have the magneto protected, otherwise short circuits would be caused. It is probable that the needs of the hydro-aeroplane will bring about a more general use of water-cooled engines for aeroplanes.

The difficulty of accurately estimating the distance from calm water when preparing to alight upon it is so serious that it is becoming quite common to use artificial aid. Some pilots carry Holme lights which, on being thrown into the water, burst into flame and give off thick smoke, thus being effective both by day and by night. If one of these is dropped while the pilot is at a considerable height he can descend by circles, keeping it in view, and thus being able to judge his 'landing.' It has been suggested that lime would be very useful in this connection, for, scattered over the surface of the water, it would discolour it and cause bubbles.

So difficult are the problems connected with the design and construction of hydro-aeroplanes that it is not surprising that many of the biggest over-water journeys have been made by ordinary land aeroplanes, the pilots relying upon the ability of most machines to float for a time in case of engine breakdown, and usually carrying some contrivance by which the buoyancy of the machine is increased. The hydro-aeroplane is encumbered by its floats, and is therefore compelled to carry a relatively more powerful engine with which, moreover, it cannot show the same capacity for speed and climbing.

The difficulty of finding the way over sea has already been referred to, and all the long-distance oversea flights have been made with positively reckless disregard of danger. Take, for example, M. Garros's flight from Fréjus to Bizerta, a distance of 500 miles, but including, half-way, the island of Corsica. To estimate the hazards taken in that voyage it is merely necessary to quote from the comments by Mr. T. F. Farman on the subject.[1] At four different moments during that voyage Garros thought his end had come:

'When approaching Corsica the reacting spring of one of the exhaust valves of his rotary motor flew off. The equilibrium of the engine was seriously disturbed, and, as Garros said, "The whole flying apparatus vibrated disagreeably." He steered for land with the intention of descending, but, having noted the centrifugal force sufficed to keep the valve working, he decided to continue his course. That accident diminished the speed of his monoplane, and also caused the pilot to lengthen his journey by deviating from the straight line. When near Cagliari, at the southern extremity of Sardinia, Garros found he had occupied two hours more than he had reckoned on. Having started with 200 litres of essence, he was conscious his supply of fuel must be running low. The sentiment of self-preservation dictated a landing, and Garros descended to within about 1,200 feet above the ground. His monoplane was, however, at that height tossed about so violently by the eddies of wind of that mountainous region that he quickly reascended to the altitude of some 3,500 feet. Explaining his final decision to risk all by pursuing his course, Garros said, "In spite of its insupportable vibrations, my machine flew well." However, when at a distance of about seventy or seventy-five miles from land he noticed he had only twenty litres of essence left! At that moment no land was in sight, and the wind rising, Garros was unable to judge whether he was making progress. He admits his anguish at that time was intense, especially as he was more than once a victim of mirage. He thought he saw real land and steered toward it, but the illusion vanished. At length, at about thirty miles from Bizerta, Garros's heart was rejoiced by three black specks on the sea. They were three torpedo-boats sent to meet him. In order to make sure he was not mistaken Garros stopped his motor to descend, but when he tried to start it again the exhaust valve refused to work. The pilot considered his fall into the sea inevitable. However, at the last moment, when at no more than 300 feet from the surface of the water, the motor started working again. Escorted by the torpedo boats, he reached land. His essence tank was as good as empty.'

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[1] *Field*, October 4, 1913.

With efficient wireless apparatus it would, of course, be possible to keep in touch with steamships and so to ascertain one's position approximately. But this would require apparatus and organisation of traffic not yet attainable.

It is not impossible that some quite radical divergence from all existing types may prove the solution of the difficulty. As illustrating the fact that other methods are being tried, a 'Bristol' experimental seaplane may here be referred to. This machine gets up speed in the water by means of marine propellers. Its under-water structure may be roughly described as consisting of legs, to each of which are attached small fixed rigid inclined planes. With gathering speed, under the influence of the water-screws, these planes lift in the water, and at a very small speed the boat-fuselage lifts clear, and the upper part of the legs, with their top two or three planes, becomes visible. With increasing speed more and more of the planes lift clear, and the weight of the structure is borne on those at the lower extremities of the legs, and to a great extent and increasingly, of course, by the pressure of the air on the main flying wings. Then the pilot switches on the air propeller, in this case a tractor, and

'Aeronautics']

BRÉGUET SEAPLANE

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the whole machine is almost immediately clear of the water. The air propeller is so contrived that, when not revolving, the blades come to rest in a horizontal position, and are in no danger of fouling the water. It will be readily understood that a craft embodying a hitherto untried system cannot be made a success without hard work and perseverance. Many difficulties have been encountered and overcome. It was necessary, for example, to use an engine of greater power than the average aeroplane motor, and the usual troubles were experienced. Numerous mechanical problems arose as the work went on, and were solved, it is hoped, satisfactorily after repeated experiment and trials. The machine has now been flying well, but whether it can yet be pronounced a complete success it is too early to say. A matter of this kind can, after all, only be proved by experience.

A few practical points by a seaplane pilot concerning hydro-aeroplaning may here be given:

'The sea is much harder than it looks, and when it looks most serene it is the most deceitful; when descending to alight on its surface on a calm day, be very careful and "feel for" it in the same manner as landing at night on shore. Always leave yourself room to do this on a smooth day, as if you try a steep descent, you are as likely as not to dive straight into the sea before you know you have reached the surface, and then you will find the truth of the statement as to the hardness of the sea-water.

'You will not be received with joy or commiseration on returning to your station with the mangled remains of a seaplane being towed after your bruised and sore body—possibly containing a broken bone. Experienced aviators who attempt steep descents on a glass-like sea should be put back into the beginners' class as a reward for folly.

'Remember also on such days that you will probably require a long run in order to get the seaplane to rise.

'As an example of how difficult it is to see the surface of the water on a clear smooth day—shallows lying under several feet of water have several times been reported by aviators as dry land.

'Don't forget the following points—

'1. Never go out without your engine pulling properly. You can land anywhere on the sea on a fine day, but you won't find any workshops to assist you.

'2. If your engine begins to fail, get as quickly as possible to the nearest enclosed or inland water to descend on, and do not, except as a matter of great urgency, attempt to go any distance away from a good landing place, unless there are fair stopping places *en route*.

'3. Experience will show you that invariably the sea is much rougher than it appears from above, and if the wind is blowing on shore, you may not be able to turn, after landing head to wind, in order to beach your machine; therefore on such occasions, land as close to the beach as possible.

'4. Remember that water on the wires will run your battery down, and bear this in mind when you moor your sea-plane on the water.'

CHAPTER XIV

SUMMER AND WINTER FLYING

APART from the question of temperature most pilots will agree that flying in winter is more comfortable than flying in summer. In England there is no more wind in the cold months than in the warm months, and the air is certainly much steadier on account of the reduced power of the sun. It is possible also that in the summer, on account of the greater length of the day, the average pilot has a much more exacting time of it. He is apt to be called up early in the morning, and often continues flying until nine o'clock, or afterwards, in the evening. This makes it far more difficult to preserve that regularity of meals and rest which is so desirable.

On the general question of clothing, it will be admitted that, in these days of machines with more or less completely closed-in fuselages and in which the pilot is protected sometimes by a wind screen, the need no longer exists for Arctic clothing, even in the winter. The head, however, is exposed, and since the position is somewhat cramped, and there is little opportunity of free movement, warm clothing is very necessary. Even in summer the speed of the machine, and the fact that flying often takes place at an altitude of over 4,000 or 5,000 feet, make it cold. Perhaps the most suitable apparel is a leather or gabardine overall with a felt or fleece lining.

Rubber is not a suitable material for any part of the aviator's outfit. For foot-covering felt snow-shoes are very suitable and, in any case, rubber shoes should not be worn, they are very apt to slip on the rudder bar when it gets oily. A protective helmet is useful, but more particularly when the aviator is not strapped in his machine. In the case of monoplanes, a bumpy landing often results in a violent contact between the aviator's head and the cabane unless he is strapped in. The contingency of being thrown out of the machine or jumping from it is really one that need not be considered. It is extremely doubtful whether any safety helmet would be of any value in the case of a very bad fall. In the early days this had to be considered because landing accidents were much more frequent. The whole aspect of aviation is changed in this respect, and in the course of a very short time it will be regarded as no more necessary for an aviator to wear protective clothing than it is for a railway passenger to attempt to defend himself against the risk of injnry in a collision.

On all modern machines the speed is so great as to render the wearing of goggles necessary. Glass goggles are much to be preferred to celluloid or any other more or less transparent substitute. They are easier to wipe clean, and the vision is much clearer. It is, however, necessary to carry a spare pair in case of one getting broken through carelessness.

It is generally believed that a motor gives better results in cold than in warm weather, but probably there is not much difference. The idea that air-cooled engines are seriously handicapped in very hot weather may be dismissed, the speed of the machine being quite sufficient to render the cooling efficient. Air-cooled engines have been used on aeroplanes with success even in the Tropics. It is usually to be found that if an engine is overheating it is due to some other cause than the temperature of the outside air.

Flying in very cold weather and flying at very high altitudes at all times of the year incurs risk of the carburettor freezing. The carburettor should be shielded.

In a flight at Hendon,[1] in April 1913, a snowstorm was encountered at an altitude of 7,000 feet. The oil in the gauges was frozen, and warmer oil flowing in caused the glass of the gauges to break, drenching the pilot with oil. This is a contingency which must be guarded against, and it should be remembered that great cold will be found, even in the summer, when a height of two miles or more is attained. For high altitude work oil that will not easily freeze is the subject of experiment.

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[1] G. H.

CHAPTER XV

THE FUTURE OF FLYING

AFTER the first exuberant enthusiasm aroused by the conquest of the air there was a reaction due to such sobering influences as the frequent accidents, the heavy cost of flying, and the discomfort in which it was carried on. So that for a long period it was maintained by many people that the only field in which aerial navigation would develop was that of war and preparation for war. They argued that the submarine was a parallel case, but in that they overlooked the very important fact that a submarine vessel is an extremely costly craft that could, if it offered any attraction at all, only appeal to millionaires. As a matter of fact it offers no attraction at all. Submarine navigation is not the delightful thing pictured by Jules Verne in his famous story, but is a chilly, uncomfortable, wearying business without any compensation in the way of glorious and extensive views of life in the ocean depths. It is scarcely conceivable that there will ever be a demand for the private submarine.

At the outset, therefore, aircraft are in a very different case. No one has ever ventured to deny the fascination of the air. Tens of thousands are 'called' by it. The mere fact that so many lives have been lost, not by sailors and soldiers in the path of duty, but by enthusiasts

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and experimenters, is sufficient proof that men count the cost but little. The death-roll has steadily increased, although it is demonstrable that the rate of mortality—that is, the number of deaths in relation to the number of aeronauts and the distance flown—is steadily diminishing. But the figures are sad enough, and they may well have checked the aspirations of thousands who would otherwise have joined the ranks of those who fly. Yet, in spite of the loss of life there is a constantly increasing accession to the number of flyers, so that each year sees the total enormously enlarged. What is far more important is the fact that each year eminent scientific men and engineers are joining in the study of the problems of flight in the full realisation that aerial navigation is no mere dream, and is not merely a means of play but a serious business that must have a profound effect upon human interests.

In 1912 and 1913 the Governments of Great Britain, France, Germany, and other countries began to impose restrictions upon aerial navigation, first, for the purpose of safeguarding the general public against accidents, and secondly, for the purpose of preventing espionage by foreigners. In the case of Great Britain the regulations imposed were so drastic that, added to the other handicaps under which aviation laboured, they caused some people to say the days of civilian flying were numbered and that it was clearly the intention of the Government to keep the air for military and naval aircraft. That the regulations had a somewhat chilling effect cannot be doubted. At the same time it can safely be asserted that no Government, even if it wished to, could interfere so much with the liberty of the people as to make private flying impossible. Nor can it be supposed for a moment that the most reactionary Ministers have ever imagined such a state of affairs. Legislation may have been over-drastic, but it is important to recollect that it was somewhat hurriedly framed to meet what was believed to be an emergency. It stands to reason that only such portions of the enactments as are strictly necessary will endure. From time to time there will be amendments to this legislation, and the needs of the situation of the moment will be met.

In view of the difficulty of recognition by aviators of the prohibited military zones in France and Germany, the feasibility of staking out an aerial highway from Paris to Berlin has been discussed. A scheme for erecting signs visible at a distance of two and a half miles at a height of 3,000 feet was proposed in 1913; and some years before the question of aerial routes had been considered. It is easy to imagine a way in which development might take place. The use of public commons and parks will, of course, be denied to flying machines, but there will be a great extension of the practice of aeronautical societies acquiring grounds for flight. With the extension of flying, these societies will spring up everywhere, and their flying grounds will be maintained by subscriptions and by money received at the gates. There will be flights from one ground to another, and there may be interclub competitions. The step will be a short one to regular aerial routes and passenger-carrying services. Already a beginning is in sight. Flights between established flying grounds are frequent. Aviators are becoming familiar with certain routes and with the aerial conditions encountered in them. They are finding out the good landing-places on these routes. It will not be long before landing-places are marked on special maps and indicated by some sign on the ground.

Side by side with the development of machines that are safer, and able to perform various useful services in other than warlike directions, will gradually grow up increased facilities for civilian flying. At the moment of writing there has been little progress in this direction for some time in England, but in France and Germany the provision of frequent landing-places has been made. This, although not required for military purposes, will be necessary before there can be any great extension of civilian flying. Probably with the increased reliability and efficiency of the machine all that will be wanted, even in a difficult country like England, will be landing-places fifty miles or more apart. At these landing-places there will be sheds, mechanics, supplies and material of all kinds. No town of more than ten thousand inhabitants will ere long be able to dispense with an aeroplane station. And when the movement in the direction of increased facilities once begins it will be very rapid, for various helping influences will come into operation. For example, the increased demand for machines will result in production on a larger, and, therefore, more economical scale. Competition will bring down the price of engines. Insurance carried on over a much bigger field than is at present possible will bring the rates down, and aviators will be able to co-operate in sharing the expenses of various kinds. It is not at all difficult to imagine that the insurance of aircraft will develop on similar lines to marine insurance, so that ultimately an aerial Lloyd's will become established, setting up standards of constructional quality and security, and facilitating aerial navigation, keeping a register of all aircraft, and issuing certificates.

Bearing on this desirable development will be the result of the study of the regular currents of the atmosphere.

Besides the trade winds, which are of so much value to the commerce of the world, there are a large number of regular movements in the atmosphere at various altitudes, the exploration of which is now beginning. To the Germans we must give credit for valuable work in this direction. The main German air-currents are now known and charted, and use of this knowledge is constantly made by aeroplanists and dirigible balloonists. Prof. Hergesell, as already said, mapped out the regular winds of the North Atlantic, and future aerial traffic between Europe and America will depend very greatly upon a knowledge of these currents. British meteorologists—Dr. W. N. Shaw, Mr. W. H. Dines, Mr. C. J. Cave and others—are doing valuable work in this department. It has long been supposed that migrating birds avail themselves of regular winds that blow at certain seasons and at certain altitudes. There is no doubt that a more intimate knowledge of the atmosphere will show to man, now that he has flying machines with which to navigate the air, great aerial routes, some seasonal and some permanent.

The present limitations of flying are due in some measure to repressive legislation. Other causes are, as already said, cost, discomfort, and danger. It is extremely fortunate that the flying machine was not from the outset produced at a price enabling a large public to use it. Clearly, had there not been severe restrictions to the ease with which aviation could be pursued, the loss of life would have been tremendous, and quite conceivably the situation created would have become so acute that experiment itself would have been stopped and the whole thing come to an end. The world was ill-prepared for flying, and already the progress of flight has been so rapid that it has been, and continues to be, ahead of anything that could be done to keep it within reasonable bounds. The history of flying is the history of men exceeding their powers and of presuming to battle with forces of which they are profoundly ignorant. Imagine the whole population free of the air under these circumstances, and it is easy to conceive the probability of confusion and disaster of the most terrible kind.

Improvement of apparatus is taking place, chiefly, no doubt, with a view to satisfying naval and military requirements, but also in a large measure due to that restless desire for perfection which inspires many of the brightest minds to labour without hope even of material reward. Those who have read this book so far will have gathered what, in certain directions, in the opinion of the authors, will be the development of the flying machine. Mention has been made of the need for a dual power-plant giving alternative power in case of the stoppage of one engine; of machines that will fly with their engines working reliably at a very small proportion of their maximum power, thus rendering them far less liable to break down; of machines with variable wing area and angle; of machines that will land at very low speed; and of improved construction generally. All these things are in sight, but in order that flying when safer and cheaper may become really popular, machines will have to be more comfortable. Already there is a healthy tendency in this direction. Seating accommodation is less cramped, and pilot and passenger are usually protected from the worst of the wind and cold. Machines, too, are very much cleaner than they used to be. The principal drawback appears to be the noise of the motor, and there has really not yet been time to attend seriously to this detail. A motor silenced or partially silenced is desired for military, if not other reasons, but to silence the rotary motors so extensively used is impossible. As for stationary motors, they can be partially silenced; of course, at some loss of efficiency. Hitherto silencing has not been an absolute necessity. It has been far more important to get on with practical flying and the overcoming of other difficulties. It may be said, however, that aeroplane engines can, and will, be silenced when the need to do so arises. Still further increase of comfort will follow from recognition of the fact that the fuselage of an aeroplane can have a greater breadth than is given to it in many machines. In early designs it was supposed that the narrower the fuselage the less was the air-resistance. This, of course, is true, but with a properly stream-lined shape the addition of a little breadth makes a scarcely appreciable difference in the amount of air-resistance.

Aeroplanes will, of course, develop on many different lines, and the tendency to do so becomes more noticeable every year. In one direction a machine that will carry four or more passengers, or their equivalent weight in mails, is being evolved. It has begun to appear in fact before its time, for it is impossible to contemplate a general employment of aeroplanes carrying more than one or two persons unless they can be immune from engine failure and forced landings—not always on smooth, unencumbered ground. The problem of dual power-plant must be solved before serious development can proceed along these lines, but that problem may be said to have been solved, since aeroplanes have already flown carrying one or more spare engines. No development can, of course, take place unless it can be made to pay. In the first place machines of a new type are, as often as not, produced purely for experimental purposes, although

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B.E. BIPLANE

plane']

LAUNCHING A NAVAL BOREL MONOPLANE

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sometimes they serve the uses of advertisement. It may be taken as certain, however, that in the case of the big load-carrier a commercial demand has begun to manifest itself. In France, in 1913, a regular service of mail-carrying by aeroplane was inaugurated, and was carried on from Paris to Bordeaux in connection with the West Indian and Central American mail-boats. This and other mail services are referred to in Chapter XVIII, page 298.

The aeroplane carrying a number of passengers will, when machines and fuel are cheaper, be commercially possible as a means of quick passenger transport.

From the nature of nearly all the flying that has been done hitherto, from the struggle for the attainment of mere speed or high altitude, and from the showman element which has necessarily played so large a part in aviation, most people have been unable easily to understand in what direction flying is likely to become of real service to the community save in connection with military affairs. False ideals have been created and pursued owing to the need to obtain popular support and to attract crowds willing to pay for admission to an aerodrome. Even the liberal prizes given by private individuals and by newspapers have, in many cases, been offered for purposes which help little towards the development of the really efficient and useful flying machine. Nearly all the competitions in the first few years were speed or altitude tests, pure and simple, and even in trials in different countries of machines suitable for military purposes the conditions were very little better. The practicability of flying was sprung so suddenly upon the world that very few people were qualified to guide it in the best channels. It was unavoidable that many of those who had control in aeronautical matters did not possess the expert knowledge that would have enabled them to set up truer ideals.

It is, or should be, an axiom of mechanical flight that the most efficient machine is the one that transports the greatest load in the shortest time for the least expenditure of power. In these terms we sum up everything needful. Now, in the absolutely open aeroplane competition, the prize-winning machine is nearly always the least efficient. For example, two machines may be considered: one carries a load of 1,000 lb. at forty miles per hour with a 50 h.p. engine, the other carries 600 lb. at sixty miles per hour with a 100 h.p. engine. Clearly, the first machine is the more efficient. Not only so, but it is the more economical; the reduction of engine power means a saving in initial cost and in running cost. But in the speed contests of to-day the high-power machine usually wins. It is a specialised type and requires skill in landing. Of more use than speed contests would be minimum and maximum speed competitions, but they are not popular. There can be no doubt at all that the machine of the future will be of a very high order as regards aerodynamic efficiency; it will not be a 'tea-tray' driven by 200 h.p.; it will necessarily possess the quality of variable speed. The open competition does not encourage the designing of essentially improved vehicles. A new condition of the Gordon-Bennett race introduced in 1914, by the way, requires that competing machines shall be able to fly at a certain minimum speed.

Endurance and hardiness being the most desirable qualities for an aeroplane, one of the best competitions possible would be one in which the flyers had to travel across country carrying their own repair outfit and materials, and prevented by the rules from getting outside help. Such a competition would mean that one, or even two, mechanics would be carried as passengers. Of course, it would be permissible to obtain fresh supplies of fuel and oil when required. The machine that flew the longest distance and remained the longest time away under these circumstances, but yet was able to return to the starting point intact and in flying order, should win the honours.

The experiments carried on by M. Louis Blériot, in 1913, with an aeroplane designed to fly from and to a cable-way, instead of either to earth or to sea, possibly indicates a new type of craft capable of utilisation in various important services. Clearly, it would take the place on many occasions of the hydro-aeroplane, even though it may be assumed that the latter will soon be made superior to many of the troubles to which it has hitherto been subject. If the cable-plane, or the deck-plane, be perfected, as it probably will, the world will have an aircraft that will not only co-operate with warships wherever they may be, but will also be more efficient than any existing aeroplane designed either to alight upon land or upon water. The deck-plane may be built without the usual heavy and cumbrous wheeled landing carriage or the still more impeding floats or boat. The simplest under-structure will serve, and this will mean an enormous gain in flying efficiency. There will be very little 'bottom hamper.' The wings will be made unsinkable, this for emergency when a descent into the water is unavoidable; but normally the deck-plane will use the cable contrivance, which could be stowed away when not in use. Passenger liners and mail boats, moreover, could be equipped with cable and deck-planes, so that further increased mail facilities are among the advantages foreshadowed. It is more than likely, also, that this type of aircraft could be used for overland purposes, although it would require the provision of frequent suitably equipped landing-places. This, of course, is pure speculation.

In launching into flight it is clear that with such a contrivance a smaller power is sufficient than with machines that must get up their flight speed on the rough ground or the resisting water. It follows that the deck-plane could fly with economy in power-plant. It will be remembered that in the early days the Wright aeroplane took the air off a special rail launching apparatus, and for this reason it was necessary to equip it only with a small power engine, so that it was a remarkably efficient machine aerodynamically. The cable way was invented by M. Levavasseur, but M. Louis Blériot was the first to put it into practical use.

In the direction of cheaper aeroplanes development is even now possible in view of the often overlooked fact that flight can be maintained with engines of small power. This, of course, was known long ago, and in their first experiments the Wright Brothers and Mr. A. V. Roe flew with low power, the latter with an engine of no more than 12 h.p. It would now be possible to construct an aeroplane for a small engine that would not only have good speed quality, but would be in every way an efficient craft. The chief thing that is required is a reliable engine of low power, but until a demand arises, or until there is a prospect that such an engine would find a ready market, it will not be produced. A machine of the kind described need not cost more than £150 or £200, even in the early days; but all the while there is no commercial inducement to designers to produce an inexpensive machine, and all the while they are pre-occupied with producing either racing or military craft, the small cheap single-seater will not appear. As already said, the way has been prepared for it.

It is now possible to design aeroplane wings with a section which requires less force to drive them through the air in proportion to the lift or load carried than was the case a short time ago. This is largely due to tests in experimental laboratories with models, chiefly in France, by M. Eiffel, and in this country at the National Physical Laboratory at Teddington, where so much valuable research work has been carried out.

Perhaps the most important discovery has been the proof that the upper surface is responsible for about two-thirds of the entire lift, and that only one-third is given by the under surface, from which it follows that the design of the under surface is not the only important factor, but that the shape of the upper surface requires very careful consideration. When in flight the plane receives a certain amount of support by the air on the under side being compressed, while on the upper surface the pressure is reduced and a partial vacuum formed, which, in popular language, holds the plane up.

A very large number of shapes of upper surface have been tested; of these, one which calls for remark is that first embodied in a flying machine by Mr. Howard Wright. This wing, to which a brief reference was made in Chapter V, has a double camber on the top side. Seen in end view it appears like two wings in tandem, the leading edge of the second joining up to the trailing edge of the first; the under surface is one bend or camber from front to back, as in the ordinary wing. The effect in flying is to give a greater reduction of pressure on the upper side, and thus increase the amount of lift per unit area, and at the same time to reduce the force required to drive it through the air, so that for every 15 lb. of lift, only 1 lb. is required to drive it along.

One of the most desirable qualities in a flying machine is range of speed—enabling it to fly at a high speed on occasion, but to leave and alight upon the ground slowly. It should be remembered that at a given angle an aeroplane will only fly at one speed; no matter how much power be added, this speed cannot be increased or diminished, because the weight to be carried is constant. Increase of power will cause it to climb, and decrease of power will cause it to descend, but to achieve different speeds with different power the angle must be altered. The weight is carried entirely owing to the speed, and, as the weight is constant, the speed must also be constant.

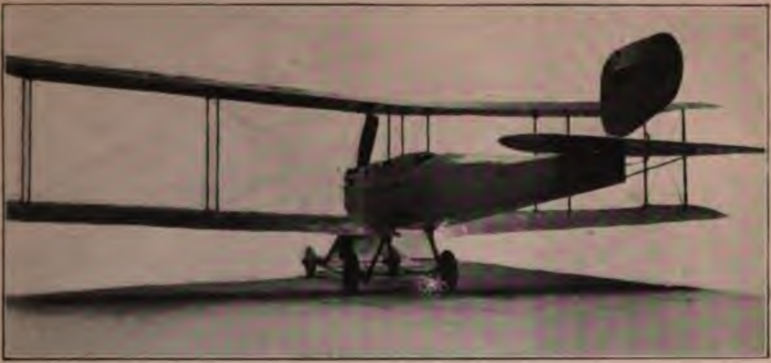
There is a very distinct limit to the angles that can be used economically. When reduced below a certain figure, the lift declines; at some of the zero angles it changes from an upward into a downward pressure. As the angle is increased, the lift being at right angles to the surface produces a backward as well as an upward force, and another danger-point is soon reached. In most planes, these extreme or 'danger angles' are from − 1 to + 12. In the Howard Wright section, angles from − 2 to + 20 can be used, so that a large range of speed can be obtained. In practice this is found to be about 110 per cent. of the lower speed.

Attention must be given, not merely to swift climbing, but to steep climbing. It is one thing to force a machine by sheer engine power at a great horizontal as well as vertical speed; it is quite another matter to secure that vertical speed without tremendous forward velocity. Unfortunately, swift climbing on present-day machines is done at a comparatively small angle of ascent. The swift climbing, as already remarked, is attained—and it is a clear advance on previous attainments—but it is not obtained in the ideal way. It has always been the principal argument of the helicopter 'school' that the craft they advocate will climb vertically. Now, without looking for anything like a vertical climb, aeroplane designers might reasonably seek to secure a steeper ascent than is at present attainable, and for military reasons, if for no other, it may be taken as certain they will be called upon to do so. The speed-range machine that has a very slow minimum safe speed is clearly a step in the right direction, for it should be no very difficult matter to employ the marginal power for climbing. Machines so contrived will obviously be capable not only of climbing steeply, but also of landing slowly in confined spaces, and with that quality opens up a vast vista of new possibilities of the aeroplane for military, commercial, and passenger services, and even for use over and in cities. It may be admitted that the quality is not yet attained, but it is clearly within view of attainment.

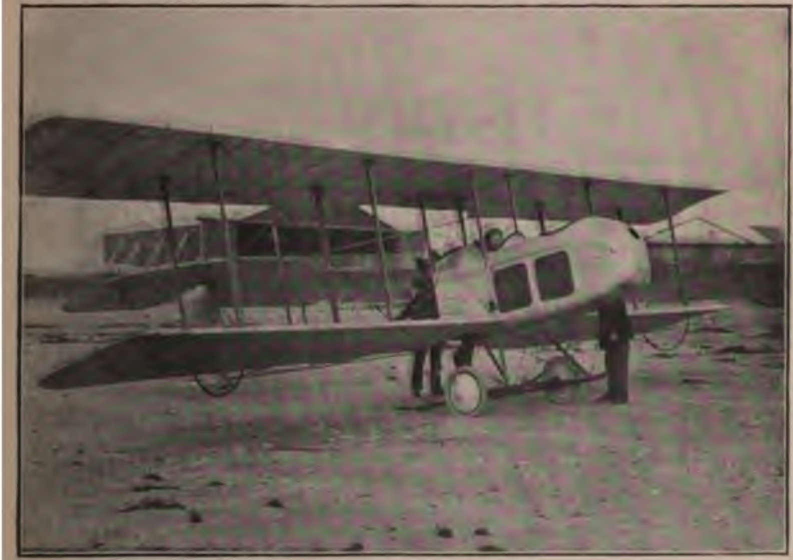
Apart from the interesting development of the aeroplane itself, with variable wing angle and plane area and camber, an enormous field of design and experiment with power plant and propeller form, worthy of the best engineering and scientific talent in existence, is opened out. That the difficulties are formidable will not, assuredly, prevent this talent being applied.

With the production of inexpensive aeroplanes, and with an all-round improvement in the art of flying, there will be a great increase in the community of aeronauts. As Mr. Henry Farman says elsewhere in this book: 'In the course of a few years the good pilots of to-day will appear, in the eyes of the pilots of that time, to be no more than mere novices. With the improvement of the best pilots the average pilot's skill improves and the difficulties of the beginner diminish. With more reliable motors, flying will be so safe and the knowledge of flying and the necessary prudence so common, that practically it will have lost all its riskiness.' There can be no doubt whatever that in the course of a very few years there will arise a class of private flyers who will fly purely for pleasure, and these will develop the use of flying machines for regular travelling. It is often said that flying is all very well, 'but the city man will never go to his office in an aeroplane.' In the same sense it might be said that no city man goes to his office in a railway train, for it cannot be denied that, having stepped out of his morning train, he has platforms, stairs, lifts, and usually streets to negotiate before he is able to begin the work of the day. The private motor-car is, of course, an advance upon the railway train for those who can afford it. But to those who live at a great distance from the City the railway is essential as a means of regular communication. With the safer and cheaper flying that is inevitable, it will become the fashion to fly, at any rate, part of the way to work. Aerial motoring will be combined with road motoring. It will be a delight to the City man to step into his flying machine close to his own house and do a fifty or sixty mile spin to an aerodrome or aviation station somewhere within four miles of the Bank. There he will step into his motor-car. It is not necessary to attempt any more distant forecast, but what has been said will notably, ere long, be fulfilled.

Too much emphasis cannot be laid upon the fact that much of the present risk in flying is due to imprudence and lack of knowledge, and that with the increase of flight education, and with the prohibition of flying



BRISTOL BIPLANE



VICKERS' ARMED BIPLANE

by persons who are physically and morally unfit, folly and imprudence will be almost eliminated. In the light of knowledge of the present day, trans-Atlantic travel in the sixteenth century in small sailing vessels, navigated by men who were almost entirely ignorant of what waited them in their journeys, was folly that almost amounted to insanity. So will the work of aviators of to-day appear to the more enlightened flying men of a decade hence.

One of the principal immediate inducements to development outside military aviation will be private sport. There is not the slightest doubt that in the course of a year or two hydro-aeroplane contests will be a part of the regular programme at Cowes and other fashionable regattas. In America, where the great lakes and big waterways give splendid facilities for hydro-aeroplaning the dawn of aerial yachting has already appeared, and at the moment of writing there is a glimmering of the dawn in Great Britain. For two reasons the dawn has been delayed. There has been some discouragement of private flying owing to Aerial Navigation Act prohibiting flying over certain areas, and particularly over the coasts. Then the price of a hydro-aeroplane has been not less than £1,300 or £1,400. For the rest, the same circumstances which, as already shown, will result in a reduction of the capital outlay and also of the running costs of overland machines, apply equally to hydro-aeroplanes.

On this question of the future of civilian flying the following opinion has been sent to the authors by one of the foremost authorities, who has been associated with aviation from its earliest days and continues to carry on important experiments. He says:

'There is no future for civilian flying until machines can be made that have far lower landing-speed combined with very rapid climbing powers. It is too difficult and hazardous to the ordinary man to land in unfamiliar places at a speed of forty miles per hour or more. Eliminating engine trouble, the ordinary flyer who is anxious to use an aeroplane for sport or business cannot be expected to pick the exact spot on which to land if he is travelling at high speed. It is impossible to tell the exact nature of the surface of a field or common until quite close; and in England particularly fields are small and surrounded by hedges or trees, so that it is essential that the pilot should be able to descend quickly but at a low forward speed.

'A machine which can fly at twenty to twenty-five miles per hour completely in control (by this I mean not at so great an angle as to be nearly stalled) would enable a pilot to choose a suitable spot and to stop almost dead upon it. If at the last moment the surface were found unsuitable, he must be able to climb out by turning on his power and rising at a very steep angle.

'On the other hand such a machine as I have indicated would be practically useless unless its speed could be increased to at least fifty miles per hour, so as to have a net speed of twenty-five miles against a twenty-five miles per hour wind.

'It is not satisfactory if a pilot can increase his speed only by lowering the angle of incidence, for then the danger is that the angle of incidence may be so small and sensitive as to constitute a danger in uneven air.

'The combination of necessary qualities appears to indicate a light machine of variable area with relatively large horse-power and large propeller area. Actually a surplus of 400 or 500 per cent. is required, and, in my opinion, this is not far from realisation.

'Such a machine in the case of engine breakdown would, of course, be no more able to climb out of an unsuitable landing-place than any other, but it would have ten times more chance of landing without damage or accident than the ordinary aeroplane. The mere fact that it would be flying at only a fourth or one-third of its maximum power most of the time would enormously increase the reliability and durability of the engine. The chance of a breakdown would be reduced to a minimum.

'The plane-area variation required to give a speed-range of twenty to sixty miles per hour is about sixfold if the angle of incidence is unaltered, and if, as is reasonable, the angle is halved for the high speed, a plane-area of variation of threefold would be sufficient. This variation is not impossible, but the real difficulty is the maintenance of the efficiency of the wing section under the two conditions, reefed in and extended.

'To take a concrete case—a machine weighing 1,000 lb. of 600 square feet area can fly safely at from twenty to twenty-five miles per hour on 15 h.p. provided the propeller gear be reasonably efficient. With 60 h.p. such a machine could climb up about 700 feet per minute, keeping up a forward speed of twenty-five miles per hour or an angle of nearly 1 in 3 to the horizontal. This would make it possible to get out of almost any conceivable situation—that is, out of a small field encircled by high trees. By reducing the area of the wings to 200 square feet and with 60 h.p., the machine could fly at sixty miles per hour.

'As already said, the principal difficulty is the mechanical one of reefing a wing surface without impairing its efficiency. An important difficulty is that of the propeller, because the efficiency of a propeller is highest at a certain speed. It appears necessary to evolve propellers having a variable pitch.

'Granted that such a machine as is here indicated will be available within the next few years, there is no reason why a large class of people should not take up flying as a sport and why it should not soon become one of the safest and most rapid means of transit. The great inherent advantages of being able to go straight, of being able to turn corners at the correct bank, of having the smooth travelling medium of air with no road shocks, and with no liability to collision through many vehicles being on the same track, must give the flying machine a great advantage over other methods of transport.'

The reference in the last paragraph to the 'correct bank' is to the fact that a flying machine in turning a corner naturally tilts up on the outside of the turn, and the passenger is, therefore, not in the least incommoded. He has not to hang on in order to avoid being thrown over to the side. On all road vehicles, of course, the horizontal is maintained and the passenger feels a strong tendency to lurch to the side. Moreover, all land vehicles would, unless prevented, in turning tilt up on the inside of the turn, and in order to prevent that railway tracks and motor-car tracks are banked artificially to prevent capsizing.

In Chapter XVIII on the Uses of Flying many matters relating to the future of flying are considered.

CHAPTER XVI

THE AEROPLANE IN WAR

WITH NOTES ON THE SEAPLANE IN NAVAL WARFARE BY A NAVAL OFFICER OF HIGH RANK

WHILE aircraft are yet in their infancy and before they have been seriously tried in actual warfare, they have produced a profound effect upon military training and practice. They have not revolutionised strategy, because strategy is the same in all ages; the rules remain the same, although the machinery changes.

General Sir James Grierson said on one occasion, 'warfare will be impossible unless we have the mastery of the air.'[1] That was a statement that at the time found little acceptance among those who, reflecting upon the situation, realised chiefly the shortcomings of aircraft, the uncertainties of the engine, the numerous breakdowns, and the liability to be brought down by gun and rifle fire.

Their limitations notwithstanding, aircraft have, as already said, produced a profound effect upon military training and practice. It was only necessary to be demonstrated that a vehicle could be made that would take one or two men into the air, and enable them to survey a vast expanse of country, for drastic changes in the method of conducting military operations to become necessary. Knowing his opponent to possess aircraft a commander in the field must proceed to work in an entirely different manner from what he would under ordinary circumstances. He has not only cavalry scouts to reckon with, but aerial scouts. He must, then, take measures to screen his movements from aerial observation, and all that it involves. The difference between the work of cavalry scouts and aerial scouts is simply this: assuming operations on an extensive scale, large numbers of cavalry scouts have to be sent out, and they collect information, more or less accurate, and return with it. By the time the information is absorbed, that is to say, by the time the scouts have ridden in and reported, a period of many hours, possibly extending to one or two days, will have elapsed since the state of affairs revealed by them existed; and in that period the opposing force may have made vital changes in its dispositions. Aerial scouts, on the other hand, can do at least an equal amount of work in a fiftieth part of the time taken by cavalry scouts. They can fly, at a moderate estimate, even under adverse conditions, at fifty or sixty miles per hour, so that the state of affairs they report upon must necessarily be in existence long after the reports are handed in, for it takes more than a few hours for important changes to be effected in the disposition of a large force. The mere knowledge, then, that an opponent is served by air-craft compels a commander to adopt methods to mask his movements and, as much as possible, to move by night.

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[1] Aeronautical Society meeting, November 27, 1912.

Reporting on the British Army Manœuvres in September 1913, Mr. Prevost Battersby, who was with the White Army, wrote: 'Quite the most significant feature of the work done to-day was furnished by the Flying Corps. The morning was, as many mornings have been lately, shrouded in heavy mists, the valleys looking

'*Daily Sketch*']

BALKAN WAR. AN AVIATOR CARRYING A BOMB

'*Daily Sketch*']

STARTING FOR ADRIANOPLE TO DROP MESSAGES CALLING ON THE TURKS TO SURRENDER

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like white floods out of which the taller trees thrust their heads. It was just the sort of day that seemed to promise the least results for aerial scouting. Yet before ten o'clock Colonel Sykes, the commander of the Royal Flying Corps with the White force, had been able to communicate to its headquarters at Daventry most important information as to the position and movements of the main body of its foe. There are twenty-five aeroplanes and two airships with the Northern Army, and their headquarters are at Dunchurch, some eight miles to the north of Daventry. As a station it seems to be very favourable, there being a thick belt of trees, on either side of which airships can be moored to obtain shelter from the wind, and the alighting ground is excellent. The station is connected by telephone with headquarters and equipped with wireless to receive any messages that the observers may send. Thus an observation made fifty miles away over the Chiltern Hills, from which the Southern Army is defiling, might within five minutes be repeated to the Commander-in-Chief of the Northern Army. General Monroe, sitting at a table in Northamptonshire with a map before him, would have been able, a few hours after the declaration of war, to enter upon it, one after another, the exact position of the columns advancing against him in Oxfordshire, Bedfordshire, and Buckinghamshire, as the voices of those flying scouts of his called back across the intervening space the movements of the masses of men and guns beneath them.

'A year or so ago the utmost he could have expected to hear, with the expenditure of much effort by men and horses, some twenty-four hours later would have been no more than a rough approximation to the reality, on which he might have hesitated to base his plans. We have thus had at the outset a striking illustration of what the command of the air may mean to a commander—a command that cannot be obtained by the mere possession of aeroplanes, but by the possession of more aeroplanes than one's opponent. The observers to-day were much bothered by the mist, especially about Oxford, in the Thames Valley, and along the edge of the Chiltern Hills, but none the less they were able to report with astonishing exactitude the position of the Southern camps and columns, and it looks as though army tents in the future will have to be made of green canvas on which ingenious designs may be painted to deceive the soaring eye.'

The suggestion that tents will have to be coloured is important, but it overlooks the fact known to every pilot that any series of objects in regular formation, no matter what their colour, can easily be seen. Modern conditions may, therefore, require, whenever possible, that branches of trees and portions of bushes should be attached to the tops of the coloured tents in order to baffle an aerial observer. It is considered in military circles that a dull reddish-brown colour for tents is least conspicuous from above. But speculating upon what will be done under different circumstances, when necessity makes strange and unexpected demands, would lead to interminable discussion.

The new time factor introduced is obviously of tremendous importance. The need to mask movements from aerial observation is equally important, although the effect cannot yet be altogether foreseen. No one knows what measures will be adopted to this end. But no matter what may be done it must, of necessity, constitute a severe handicap. Ordinary methods of taking cover are scarcely serviceable under these new conditions. The very scattered formation compelled by modern weapons will apparently have to become still more scattered.

It has been suggested that troops should march under canopies coloured according to the nature of the country over which they are marching. The suggestion is sufficient to show how disturbing the existence of aircraft is becoming, for if such a device were adopted it would constitute a serious addition to the impedimenta of an army on the march, which alone would probably justify the existence of its opponent's aircraft. It is mentioned here merely to illustrate the fact that points may be gained without firing a shot. What a commander must of necessity consider is the choice of routes and positions most favourable for eluding aerial observation. The commander without aircraft opposed to a commander who is served by them, must, therefore, in the nature of the case, be at a tremendous disadvantage, even in the initial stages of operations. General Grierson's remark quoted above is completely justified, even if we take into account only the negative and indirect influence of aircraft. Everything seems to indicate that there must be the keenest possible rivalry to obtain the best aircraft and the largest number of them, served by the most highly trained pilots and observers. And this without allowing the possibility that aeroplanes could seriously take the offensive.

It has been said that the employment of aircraft will render scouting by cavalry obsolete. On this subject the following remarks by Mr. W. E. de B. Whittaker may be quoted[1] 'No army moves in hostile country without a far-flung screen of cavalry, collecting information and conveying warning. The cavalryman, from the nature of his service, is a trained scout, and until the last year or so was the only effective eye of the army. To-day the aeroplane enters to aid him in his duties. Those who have flown brilliantly at flower-shows and garden-parties are a little apt to think that the aviator can entirely supersede the cavalry scout. The aerial investigator has merely to rise to a great height, and the enemy's plan of campaign, including the hidden thoughts of the G.O.C. are divulged to him as he descends in a graceful spiral. It is so easy, so simple. One has merely to look and one sees all. Those who have the deepest knowledge of the theory and practice of war, and who, at the same time, are not ignorant on the subject of aviation, hold definitely that the aerial scout supersedes nothing—he augments. If it were possible for an observer in an aeroplane to note accurately and with great speed all that was within his range of vision, then even he would not replace the land scout. No observer, however skilled, can bring down a perfect report of what came within his view, and the haste of his actions is likely to make even that little which he is able to write inaccurate to a certain extent.

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[1] 'Cavalry and the Aeroplane,' *The Aeroplane*, August 29, 1912.

'The aeroplane observer's reports are made entirely from the use of sight. He has to rely altogether on that which he can see or imagines he can see. In this he differs greatly from the cavalryman. The mounted scout is able to acquire a large quantity of information from the inhabitants of the country. If he gains no positive knowledge he can, by a judicious study of the negative news he receives, give valuable points to his G.O.C. The conduct and bearing of the native frequently explain much. Jubilation on the part of the inhabitant means possibly that a strong force of his country's troops are in the vicinity. Despondency sometimes means that the land is not held by armed forces. Intuition and a little power of deduction carry a scout far on his way. The land scout can also read the signs of the ground. Footprints mean something to him. The movements of birds and animals unlock many doors of news. The aerial investigator has none of this. He has to rely entirely on the aspect of things from above. Masses of men, fortified positions, and entrenchments are his sole guide. The detailed work of the ground is cut off from him. He has but little time in which to think things out, and his reports are the work of crowded minutes and not of hours. He may say that a position is easy of attack because from above the natural obstacles, such as exaggerated contours and marshy land, are not obvious to his sight.'

But this is a chapter on the aviator's point of view rather than on questions of strategy, and must deal chiefly with practical flying matters. In the Balkan War the roads were so bad that there was practically no road transport of machines; the few aeroplanes that were employed did all their work in the air. And the fact that they did so shows that, hurriedly as they were acquired, they were remarkably efficient craft. But it may be taken as a general rule, aeroplanes that can be easily demounted and stowed away, either for shelter or for road transport, or for replacing damaged parts, will be desired. A quick-assembling and road-transport test was imposed in the British War Office aeroplane trials in 1912. The monoplanes scored in this test; and not only can the wings of a monoplane be quickly taken down, but the machine can be run into quite a small shed sheltered from a storm or from view. It does not appear, however, that the monoplane will have all its own way in the possession of this quality, for military biplanes are now being made in which the wings are readily detachable by the removal of a few bolts.

It has been supposed possible to make an aeroplane 'invisible,' so as to be an inconspicuous object in the sky, and therefore difficult to hit. Imaginative people have said that military flying machines should be made transparent. One would have thought that the improbability of anything of the kind would be sufficiently evident, for a little reflection will show that even a machine made of the clearest glass, unless it were minus engine, framework, skeleton, and fuselage, and the wings were perfectly flat planes, could be seen against the sky with very little less plainness than one made of opaque materials. Any effort spent in making aeroplanes transparent is certainly not worth while, and it is hardly likely that any sound military authority imagines it is. Aeroplanes can easily keep at sufficient altitude to be practically immune from artillery and rifle fire, and there are scores of essentials to be considered without wasting time on non-essentials. On the other hand, the colour of the wings may be an important consideration, and for this reason: far below the observer, with the earth for background, an aeroplane can be made very difficult to see. For example, a scouting machine, having obtained knowledge of value, might, in order to get back safely, have to run the gauntlet of the enemy's aircraft. In this event it would be important to have a machine as inconspicuous as possible. To that end it is far more necessary to consider the colour of the top of the wings than of their lower surface, or than their opacity. Anyone who has had experience in the air knows how difficult it is to see other flying machines at any great distance on either hand or below. The white wings in general use are the easiest of all to see, and for that reason they will probably soon be abandoned in military and naval use. The tops of the wings will be coloured dull green, grey, or khaki, and the scout who wishes to evade an opposing aircraft will not necessarily fly high, but will often find safety in keeping as low as possible, knowing that his machine flying 3,000 ft. or 4,000 ft. below, and against the usual sombre-hued, chequered land, is likely enough to pass unseen, or, if seen, would be an exceedingly difficult object to hit. From a good height even the ordinary white aeroplane is not easy to see; it appears very small, and its movements seem extremely slow.

In peace manœuvres it is customary to set a limit to the altitude to which aircraft may descend to take observation, on the assumption that their destruction would be inevitable by rifle or gun fire at a certain height. After the manœuvres of 1913 instructions were issued for use in army training in which it was laid down that aircraft are to fly, as a rule, at not less than 3,000 feet when exposed to rifle fire, and when artillery is underneath them this altitude must be increased by another 1,000 feet. Under misty conditions it is left to the pilot to drop lower if objects cannot be distinctly seen. As a rule, observers in aircraft are best able to judge whether they are under fire or not.

The General Staff notes were as follows:

'(i.) The accurate observation of bodies of troops largely depends on two circumstances: (*a*) The background, that is, the colour of the ground on which the troops may be at the moment; and (*b*) movements, *i.e.* troops on the move are far more easily seen than when they remain absolutely still.[1]

'(ii.) A column of troops moving along a white or light-coloured road can be easily seen from almost any height, whilst an extended line of infantry scattered on the grass amongst small bushes will seldom be detected if they remain still. Troops should on no account look up at aircraft, for nothing is more conspicuous than men's faces.

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[1] Not very clear.

'(iii.) When troops are marching along a broad road it is advisable that strict march discipline be maintained, the troops being kept well to one side of the road, so that the remaining side, if kept absolutely clear, will look like the whole of the road, and will probably not attract the observers' attention.[1]

'(iv.) Troops in column of route on a narrow road may escape observation if they at once take cover on either side of the road and remain absolutely still, close under the hedges.

'(v.) Woods, belts of trees, high hedgerows and villages all offer complete shelter from observation if taken advantage of when the aircraft is still at a distance.

'(vi.) When moving over country in extended order or in small columns, troops should take cover under the nearest trees, hedgerows, or patches of gorse and bushes, lying still, close under the edge of such vegetation, until the aeroplane has passed on.

'(vii.) Formed bodies of infantry must be got under trees or into woods if they are to escape observation, for in the open they are certain to be seen.

'(viii.) Artillery will probably be unable to conceal either their guns or their horses, except in very favourable country where trees are numerous and the view much restricted. Guns in the open will no doubt be easily seen, and the only hope of concealment is to occupy a position close up to a hedgerow and fire through it.

'(ix.) When troops are in camp, or in bivouac, every endeavour should be made to alter the usual formations with a view to deceiving the observer and causing him to mistake one unit for another, *e.g.*, a battery for a

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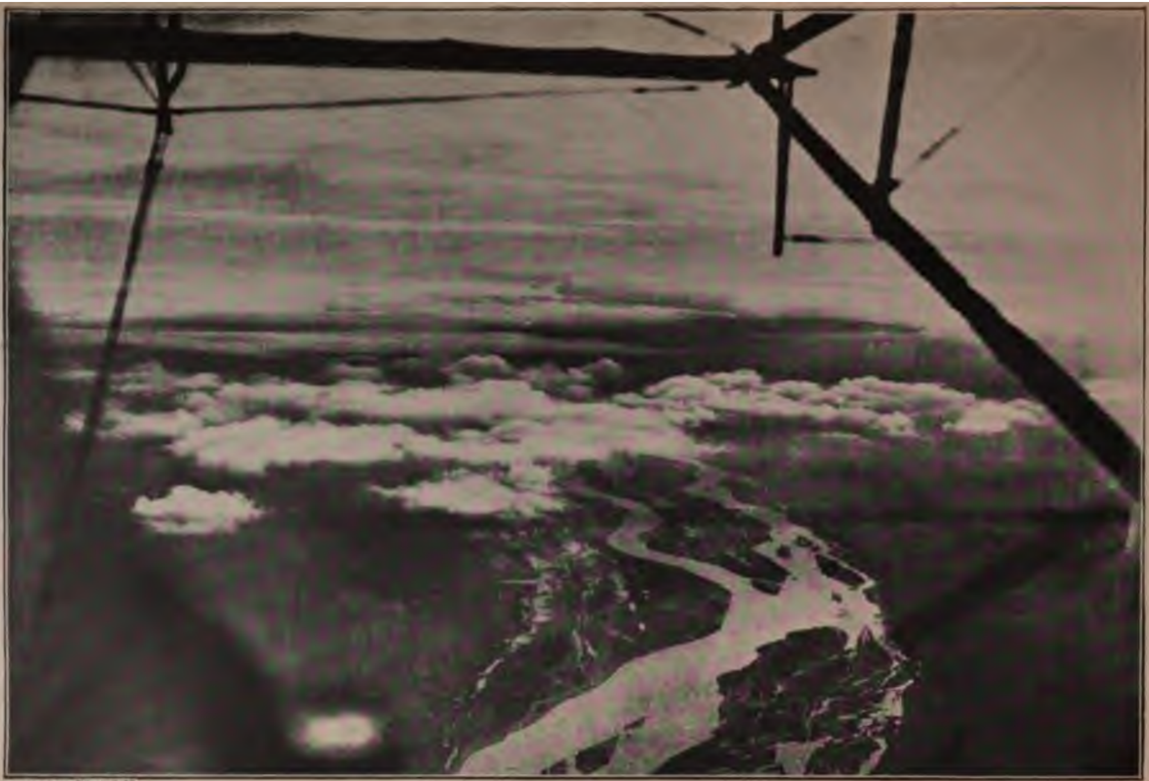
[1] This surely is an unnecessary instruction.



"Daily Sketch"]

BALKAN WAR. THE RIVER ARDA AT ITS JUNCTION WITH THE MARITZA

From a height of 4500 feet—above the clouds

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field company, R.E. Guns can be covered with tarpaulin or hay. Where feasible, cooking should be done near villages, so that the smoke does not attract attention.

'(x.) The question will often arise as to how long the presence of a hostile aeroplane is to be permitted to interfere with or to paralyse the manœuvre which may be in progress. Time may be a more important factor than discovery, and brigade commanders must judge whether it is more advisable to delay the movement by taking cover and remaining hidden, or to continue the manœuvre.'

In the Army Exercises of 1913 both the 3rd and 4th Divisions succeeded in escaping observation, and some of the cavalry were also able to remain undetected. The concealing of troops from aircraft observation having been demonstrated, the above rules are interesting as embodying the conditions under which commanders succeeded in avoiding the notice of aircraft when moving considerable bodies.

In manœuvres, of course, it is necessary to have restrictions, but it may at once be said that the rules regarding a minimum altitude are unrealistic in view of the great difficulty that would be experienced in destroying aircraft at a height of only 2,000 feet, except by the employment of considerable bodies of riflemen or numbers of guns firing by a zone method and covering a large area of the sky with their projectiles. It would be practically impossible for a few men armed with rifles, or for one gun, having sighted an aeroplane two or three miles off at a height of 2,000 feet, to get near it with their weapons, even supposing that the machine passed directly over their heads. In its passage through the range of their weapons the aeroplane would occupy not more than five or six minutes under the most favourable circumstances. They would have to estimate its distance and height, and these would be constantly changing. Sometimes an aeroplane rises and falls 100 feet or so in the course of its flight. Now an aircraft flying at sixty miles per hour, at a distance of 3,000 feet, requires of a gun that would 'cover' it a training speed of three degrees per second. The odds would be decidedly in favour of the aircraft, so much so that it may be taken as certain that in actual war airmen will, in order to obtain important information, run the small risk of being hit on any vital part of the machine, and will fly low on occasion, even over large bodies of well-armed troops. They will be no more reluctant to take risks than are cavalry scouts. Special weapons have been devised for dealing with aircraft, and to a large extent, with these weapons, the difficulties created by an almost vertical recoil and the problems of range-finding and sighting have been overcome. No army and no coast defence in the world has yet been supplied with more than a few weapons of this kind, and there are not in existence any large bodies of troops trained in their use. It is sufficient, for the moment, to observe that they have been rendered necessary by the invention of aircraft, and that they must be acquired by any nation which hopes to defend itself against an opponent served by aircraft. Only by their position in large numbers and their existence at the precise place desired at the hour of need could even the most up-to-date anti-aircraft weapons neutralise an enemy's aeroplanes and airships.

On this subject the following extracts bear :[1]—

'As regards the risks run they will, as in all warfare, be a matter for compromise. To ensure fair accuracy, aircraft will venture as low as they dare. But they can also manœuvre for safety: they can ascend out of range. Dirigible balloons would sometimes attack by night, when they would be much safer from artillery, their range being more difficult to find; and it would be easy for them to escape from the illuminated field of a searchlight if they happened to be caught in it.

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[1] 'Aircraft Attack and Defence,' by C. C. Turner (*The Outlook*, March 15, 1913).

'Anti-airship guns date from the time of the Franco-German war, when Krupps designed a weapon for high-angle fire against the French balloons. The modern weapon, however, dates from 1908, when Krupps and other German firms produced a number of different kinds of anti-airship guns with specially suited projectiles. Some of these weapons are mounted on motor-cars, but it has been found by experiment that dirigible balloons and, still more, aeroplanes travel so much more quickly, as well as having the advantage of moving in a direct line instead of by road, that they cannot be successfully pursued or kept in range by motor vehicles. The only reliable method is to have guns distributed over a large area, but care must then be taken lest falling shells harm friends. One of the latest Ehrhardt guns is a 4·2 inch weapon capable of firing at an elevation of 70°, at which elevation the highest point of the trajectory is five miles. It fires a 40-lb. shell. Krupps have a somewhat similar weapon, and there are various smaller guns, all quick-firers. The Creusot firm has produced an excellent weapon with which several batteries of French artillery are armed. Vickers also, it is understood, are supplying the Admiralty with a high-angle gun which fires a 31-lb. shell and, at an angle of 80°, has a trajectory which reaches a height of five miles.

'The projectiles would be effective even at these great heights, and in war they would usually have aircraft at smaller altitudes to deal with. The difficulty of finding the range and laying the gun has been referred to; the aircraft by being capable of moving swiftly in the vertical as well as the horizontal plane makes an extremely uncertain mark, and the art of firing at it consists not only in the use of special weapons but in combination in attack. The terrestrial gunner should seek to bring his gun to bear so early that the aircraft travels into the flattish top of the trajectory. The chances of a hit are thereby multiplied; and where shrapnel is used the chance of doing damage may be considerable. But this requires an early sight of the approaching aircraft and some quick thinking on the part of the battery commander. The latter should, when possible, divide his battery into sections and give each a zone of fire, so that the whole force in combination could cover a considerable section of the sky.

'It was very early seen that range-finding would be a difficulty, and long ago special sighting shells leaving a trail of smoke throughout their trajectory were devised. Shrapnel shell used, of course, with time fuse will commonly be fired, but incendiary shells, with percussion or time fuse as desired, will also be employed. A shrapnel shell produced by the Rheinische Metallwaren- und Maschinenfabrik is a novel projectile in that, after bursting and spreading, the head continues on its way and is capable of setting fire to a balloon. Krupps have devised a very sensitive percussion fuse which acts on contact with the envelope of a non-rigid balloon. The shell contains a solution of phosphorus in carbon-bisulphide, which spreads over the balloon, igniting spontaneously on exposure to the air. It is purely experimental as yet.

'So difficult is marksmanship it is not surprising that artillerists should look for a simpler method of destruction; the result is, many experts believe that heavy high-explosive shells made to explode somewhere within the vicinity of aircraft would, by the concussion, do sufficient damage.'

As to resistance to night attack when searchlights would have to be used, with the twin 24-inch lights now in use, the range at which a ship can be 'picked up' is rarely over three or four miles on a perfect night. In recent tests with military harbour defence lights, the lack of experience of the operators enabled ships to come within one mile of the lights without being observed on clear nights. The lights were 36-inch projectors. They were often well enough directed on the ships to dazzle those on board, but even then the observers could not see them.

One important requirement of the military aeroplane is that it should enable an uninterrupted view to be obtained, and this can be said without reference to the need that will arise in the immediate future of an uninterrupted firing field. Some military types have the engine and propeller behind the pilot, and have also sloped-back wings. In a great many aeroplanes the pilot's view is restricted by the wings and interrupted by parts of the apparatus in front of him. The latter clearly would make it almost impossible for a gun of any sort to be fired from the machine. In the British Army manœuvres of 1913 many of the aeroplanes, including some of those built by the Government, had the disadvantage afforded by the front propeller, which not only restricts the view, but is a source of discomfort, and, therefore, may involve inefficiency in military work. It appears to be quite possible that tractor machines will be discarded for all military work where careful observation is required, although, at the present stage of progress, if war broke out fast machines of the tractor type, both monoplanes and biplanes, would have to be utilised, including one-seater machines, in which the pilot would himself report on what he could see. High speed, of course, is desirable in military as in other aircraft, provided that no essential quality is sacrificed for it. And any machine that has not an independent speed of sixty miles per hour would be so restricted in its use, in that it would be unable to make appreciable headway against a strong wind, as to be little better than an encumbrance to an army.

Everything that has been said in this chapter is in consideration of machines existing at the moment of writing, but as it is possible to foretell quite definitely some of the developments that will take place in aircraft in the course of a year or so, it is only reasonable to point out that many of the conclusions here given may have to be modified. For example, the armoured aeroplane is now made, having light but tough nickel steel plating over its vital parts, rendering a machine comparatively immune from injury by rifle fire at quite small ranges. Many French and German machines are being so armoured, and it is obvious that they will reasonably scout at lower altitudes than would unarmoured aircraft. Further developments of the military machine are naturally involved in the general progress in aeroplane design. An interesting speculation on this subject[1] by one who is known to represent the views of military aeronautical authorities may here be quoted: 'From the point of view of the Army every step can be foreseen from the present aeroplane to the machine which has

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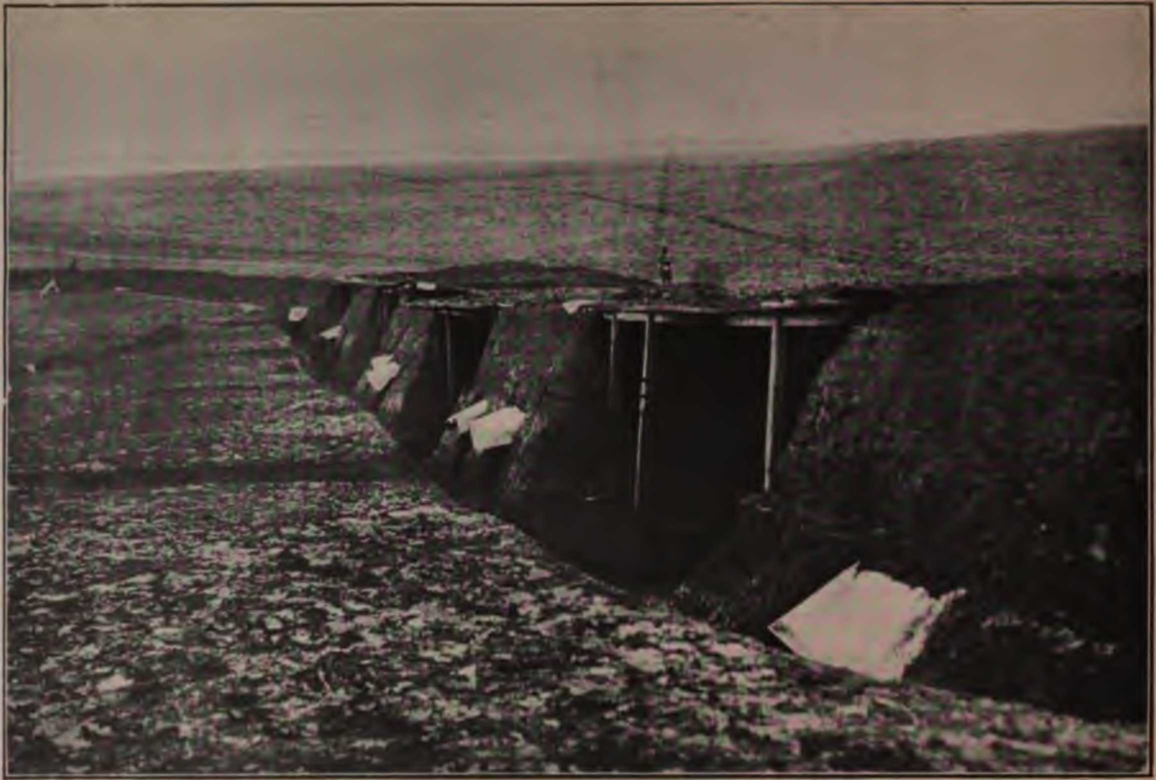
[1] 'The Future of the Aeroplane,' by Pegasus (*Times*, June 25, 1913).



'Daily Sketch']

BALKAN WAR. BULGARIAN GUNS BEFORE ADRIANOPLE SCREENED FROM AERIAL OBSERVATION

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landing gear capable of withstanding vastly greater shocks than the miserable stretched rubber device of the moment, with air and land brakes allowing of stoppage after alighting in a very confined area with safety, and with the weight carried increased from one passenger to four or five. If this increased load, say 600 lb., be expressed in terms of military utilities instead of passengers, it will be seen to exceed the weight required for armouring the aeroplane so completely against rifle fire that it can scout with perfect impunity at quite low levels in 90 cases out of 100, and in the odd ten cases the risk is small. If the rifle is quite innocuous, so is the Maxim gun. Heavier guns could certainly bring the aircraft down, but heavier guns are enormously expensive; moreover they will never be ubiquitous like the rifle, and the chances of hitting an object moving so rapidly as an aeroplane are exceedingly small, at least during the period under consideration—the next two or three years. Within such a margin of weight room can also be found for wireless of reasonably long range, say 100 miles.

'From the carriage of this extra 600 lb. can also be foreseen the aeroplane of long range—say three times the 250 miles of the machines of to-day. Alternatively in such an aeroplane the margin of lift could be utilised in duplicating the engines, while still retaining a large margin of ascensional power with one engine. In this way all reason for untimely alighting would be removed, whether the untimeliness means alighting in safety but among the enemy, or alighting on unsuitable places by reason of the 'forced descent' so commonly referable to engine failure.

'A picture has now been built up of an aeroplane which in accord with the present best can fly in a fifty-mile wind for enormous distances, without any reasonable possibility of a forced descent, and without being susceptible of being brought down by any fire except that of almost non-existent quick-firing guns. But can the weight carrying be pushed a stage farther and a machine-gun added—a small matter of 70 lb. to 100 lb. —with quite a large supply of ammunition ? It certainly can, easily, and then we can get an almost invulnerable weapon capable of flying over and cutting up the baggage trains of the enemy right away behind the battle line. If aeroplanes in adequate numbers are engaged in these offensive movements, he can never move along the roads by daylight at all. War becomes a game of chess ; every one sees every one's hand ; moves are made for positions ; failure to achieve these positions may settle the matter ; large masses of men capitulate for want of food.

' All this is not too daring a prophecy to place within three years of to-day. Shall we try for the ownership of this weapon or wait till we have felt the prick of it against our own men first ? '

The aerial observation officer must be highly trained, but sufficient has already been said to show that objects terrestrial appear so unfamiliar from above that long practice must be required for the accurate interpretation of things seen that is necessary in military work. The training of military airmen includes piloting and observation work, but nothing appears yet to have been done towards making staff officers capable of taking aerial observations. Yet several times during the Balkan War Bulgarian staff officers were taken up as passengers. Occasions will arise when it will be absolutely necessary for staff officers to ascend as passengers in aeroplanes—occasions when the services of the ordinary scout or reconnaissance officer would be without value. It frequently occurs that the plans of a commander are not revealed in their entirety to anyone except members of the staff. Plans may be made for the contingency of a retirement, only the details of the advance and attack being given to divisional and brigade commanders. At any moment, then, a commander might desire to know whether the whole of his scheme was developing; and the ordinary reconnaissance officer who was not a member of the staff could not report this without giving a laboured account of everything he had observed. On the other hand, the staff officer would very quickly be able to sum up the position, and discern wherein it agreed or differed from the pre-arranged plan. Now, the question arises, can staff officers have opportunities to obtain experience in aerial reconnaissance? That they ought to have such experience cannot be doubted, but providing them with it is a very different matter from creating a body of trained scouts.

Aviators can perform extremely valuable service by reporting to artillerists on the effect of their firing. It sometimes occurs in modern warfare that the target is either completely out of sight or is so distant that it is very difficult to judge the damage, if any, that is being done. An aerial observer, however, is in a much better position to see whether the projectiles are falling too short or too far to do damage. In the early days of military aviation, conclusive tests were carried on in the French army. Writing about these experiments in the spring of 1912, Mr. T. F. Farman, in the *Field*, says that a squadron of avions was placed at the disposal of the 25th Regiment of Artillery. It was composed of three sections, under the command of Capt. Barres. The first section comprised two mono-seated Blériot monoplanes, piloted by Lieuts. Lelievre and Vence; the second section, two Maurice Farman double-seated biplanes, piloted by

Lieuts. Bettini and Versein; and the third section, two double-seated Bréguet biplanes, piloted by Lieut. Migaud and Sapeur Brégi. Seven other avions—four mono-seated Blériot monoplanes, two double-seated Maurice Farman biplanes, and one three-seated Bréguet biplane—were held in reserve to replace any or all of the six machines in case of accident. As, fortunately, no accident occurred, they were used for reconnoitring and for making supplementary observations.

'Every day from March 4 to 13, in spite of the gales which blew so frequently at that time, all the military avions accomplished the missions entrusted to them. Those experiments seem to have shown once more that if a mono-seated aeroplane suffices for the approximate rectification of the aim of artillery, a double-seated avion is required when precision is needed. The pilot of a mono-seated machine, acting at the same time as military observer, can, after examining the effect produced by the projectiles, return and drop short notes such as "Too short," "Too long," "Too much to the left," "Too much to the right," &c. On the other hand, the military observer on a double-seated avion, having perfect freedom of mind and body, can note with precision where the shells fall, and is able to write sufficiently long and clear explanations while his pilot is steering the machine. The information thus gathered and carefully noted, being dropped to the gunners, enables them to fire with the certainty of hitting the exact spot aimed at. In the case of the artillery commander wishing to see for himself the effect of the firing, a three-seated avion is particularly useful.'

If aircraft were only of service for reconnaissance and reporting on the effects of artillery firing their use would be more than justified, yet it has been frequently assumed that the value of aircraft in war depends upon their assuming the offensive, and it has often been roundly asserted that because the powers of aeroplanes in this direction have in the past been extremely limited, they can be regarded as a negligible quantity. Already, however, the stage has been reached when military aeroplanes are armed chiefly, it must be said, for defence against opposing aircraft. No aeroplanes of the present day could carry weapons likely to inflict very serious damage upon troops on the ground. But the principal direction in which aircraft of all kinds will be able to inflict material damage appears to be by means of bombs.

For the use of bombs it is not necessary for aircraft to carry any discharging weapon, because the force of gravity will give sufficient velocity to the missile. The only points to consider, then, are the weight and construction of the bombs and the accuracy with which they can be delivered at the target. Even aeroplanes, without having their flight seriously affected, can drop objects weighing as much as 100 lb. and more; and a missile containing 100 lb. of high explosive in a metal case is capable of inflicting severe damage. It being possible to dispense with a gun for the discharge of such a missile, explosives of a more delicate and destructive character can be employed. Probably, except for special missions, lighter missiles will be carried on aeroplanes, for no machine has yet been constructed that possesses a sufficient margin of lifting power to carry a very heavy load of ammunition.

The question of marksmanship appears to the impatient to present almost insuperable difficulties, yet the problem is no greater than, although it is different from, that of naval gunnery. To fire a big gun accurately from a battleship moving at twenty knots per hour in a rough sea at a ship five or six miles away, travelling at the same, or even greater, but at any rate, unknown speed, and in a direction that cannot precisely be determined, would have seemed impossible to artillerists for more than a century after the invention of artillery. Aeroplanes have been practicable craft for not more than four or five years, and because artillerists have not yet contrived a perfect means for the accurate discharge of bombs from them, it is supposed in some quarters that the problem is insurmountable. But bomb-timing instruments are already in use, and although they are very imperfect they may reasonably be regarded as the forerunners of more efficient contrivances.

It is important to understand the bomb-timer and its limitations. The force of gravity, of course, gives sufficient velocity to the missile, which, according to the well-known law, reaches earth at the same velocity that would be required at the muzzle of a gun to send it to the height from which it fell. At half a mile this would be considerable, but at that height good marksmanship would be difficult. The bomb-timing instrument must take into account the two factors of the machine's speed relatively to the ground and its altitude. Early instruments took into account only the machine's independent speed, and left to the aviator the task of allowing for the speed of the wind by reference to a table. Also, the altitude factor was based on height over sea level, so that the marksman had to make a rough calculation, and deduct the height of the land over which the machine was passing. The only real and satisfactory bomb-timer will instantly indicate a machine's distance from the target and its speed in relation thereto. Then, the marksman will be able to tell the precise moment at which he should release the projectiles. But no matter how accurate and simple the bomb-timer may be, experience will be required in its use and in the manœuvring of the aeroplane. It will be a comparatively simple matter to hit an object provided the air be still, or the aircraft be flying either dead against or with the wind, but any side wind complicates matters, and it will frequently happen in practice that a pilot will have to make three or four attempts before he succeeds in bringing the machine to a point at which a bomb can be released in any hope of getting near the target. Much waste of ammunition is likely to occur, as in ordinary artillery.

The possibility of dropping bombs with accuracy obviously indicates a method by which aircraft can report information without the necessity of landing. Messages can be written and placed in cylinders, to which coloured streamers or a small parachute could be attached, and dropped in view of headquarters. More generally, however, landings will be made, and reports given verbally, and for this purpose it is necessary for a military aeroplane to have an efficient landing carriage enabling it to alight upon and get off from rough ground, and also it should be capable of landing in a small space.

Signalling by Morse code with flag or with a horn has been successfully carried on, and experiments have been made with soot blown from the exhaust intermittently in small or large clouds, representing the dots and dashes of the Morse code.

Wireless telegraphy will be employed for all save short scouting expeditions, and it may be regarded already as a success as used on aircraft. This subject is dealt with in a special chapter in another part of the book. Clearly, the employment of wireless enormously expedites the work of aircraft in reconnaissance. Half a dozen machines, each carrying wireless, could proceed from a base, and in the course of an hour, spreading themselves fanwise, they could cover an area of over fifty miles or so, all the time keeping up a constant supply of information to headquarters. As a general rule it may be taken that for 1 lb. of apparatus a mile range is possible. During the army manœuvres in 1913 operators on airships received 2,000 feet waves from a distance of 120 miles at the North Foreland. The apparatus in the case of the aeroplane was 80 lb. in weight, and about ten inches by eight inches by ten inches. The receiving portion weighed about 20 lb. altogether.

Numerous other services come readily within the capacity of aircraft. It is certain that they will drop bombs with effect; indeed, there is not an aeroplane in the German military service that is not equipped with a bomb magazine and an instrument for sighting and timing. But will any of the services specified render it necessary to carry a gun? It cannot, of course, be pretended that we are within measurable distance of the time when an aeroplane could carry a weapon enabling it to fight land forces or warships: beyond the damage it could inflict by means of bombs, it is not likely, for some time to come, to be formidable. The only use for a gun, then, will be to fight opposing aircraft, and the question is whether the need is likely to arise. Opinions on this point are pretty sharply divided. In France and Germany, where aerial power is most keenly debated, no steps have been taken towards general armament, although experiments have been carried on. Expert opinion in both countries is at variance. Some French authorities contend that squadrons of armed aeroplanes

'Daily Sketch']

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would be able quickly to account for the finest dirigible aloft. Many eminent German authorities, on the other hand, hold that an aeroplane's business is to secure information and get back with it safely; that it must avoid fighting, since it cannot fight with serious effect; and, if threatened by a hostile armed aeroplane, that its proper policy, even though it be the slower vessel, is to run away. They point out, and with reason, that if the hostile craft is faster by ten miles an hour—say one flies at seventy and the other at sixty miles per hour—it would take the former more than ten minutes to overtake the latter, assuming the chase began when the two craft were two miles apart. Why, they ask—under these circumstances, which clearly are such that aircraft duels would be extremely rare even in the keenest aerial war that can be imagined from established data—encumber your aircraft with guns and ammunition; and, above all, why embarrass the designer with an additional difficulty? Something must be sacrificed for the gun if one is carried. And if it is not coming into action save in situations that are very remotely likely to occur, it is not worth while. Gun-fire from an aeroplane would, of course, be extremely inaccurate, save at very short range. It may be observed, in passing, that the Germans are now mounting guns on the top of all dirigible balloons, with a view to resisting attacks from above. That attack might take the form of high explosive or incendiary bombs. It must not be overlooked, moreover, that incendiary shells could be fired from a comparatively small gun, and that these missiles would have a very serious effect, more especially on the top of the gas-container of an airship.

It may, after all, resolve itself into a question of the kind of gun to be carried. It may be presently agreed that it is not at all necessary, and therefore is most undesirable to arm aeroplanes with a view to fighting other aeroplanes. But to countries that may have to try conclusions with an enemy possessing a fleet of airships, the possibility of the gun firing incendiary bombs suggests itself.

It is well to remember that the phrase 'command of the air' is meaningless until aeroplanes can account for each other in war. At present it appears highly probable that the aeroplanes, even of the far weaker of two sides, would continue their work not even seriously menaced by the much more numerous aircraft of the enemy.

Apart from their use in reconnaissance, aeroplanes will often be employed to carry small parties of men rapidly through the air, to land them at points where they can blow up railway lines and cut off other communications, and be off again without the necessity of fighting an action. Clearly the conquest of the air means the evolution of a type of soldier far more highly educated and finely organised than the world has yet seen. Not one whit less courageous than the dashing cavalryman of the wars of fifty years ago, but scientific, cool, calculating, and self-sacrificing.

THE SEAPLANE IN NAVAL WARFARE

(The following note has been written for the Authors by a naval officer of very high rank)

The coming of the seaplane has in no way revolutionised naval warfare, but has assisted at a revolution which had been already started before its advent. The beginning of this revolution was the power of controlling the narrow seas which commenced with the advent of the torpedo-boat, making cruising in such waters for large vessels an unhealthy occupation during the night-time. The submarine increased a hundredfold the anxieties of the large vessel when within a 1,000 miles of an enemy's base. Now comes the seaplane to give eyes and ears to the short-sighted and deaf submersible. Both by night for the destroyer and by day for the submarine, the difficulty is not to sink its adversary when located, but to locate him and get into his proximity. At night, the difficulty is very little lessened by the help of aircraft, but by day the assistance is enormous; waterplanes, when intelligently worked, can give instant notice by wireless to the mother-ship of the submarines, and enable her to send out her comparatively slow-moving children to arrive, unseen, across the track of their large and speedy enemy.

The next rôle which the waterplane will be called upon to play in war time is the hunting of the submarine. From the difference of size and background, it is certain that the aeroplane will always see the submarine before she is herself discovered—for the submarine, like the whale, cannot always remain under water. It will, therefore, be one of the duties assigned to aircraft to find the submarines, and either to knock away their periscopes by automatic gunfire, or to assist the destroyer to hunt them in order to make them run their batteries down; for, when a submarine's batteries are exhausted, she becomes a surface craft, and is at the mercy of the smallest destroyer that floats on the ocean.

In this latter way, the seaplane becomes an offensive craft, but undoubtedly its principal duty will be to act as a scout. Although its great speed enables it to cover a large area of water in a very short space of time, yet its lifting power being limited, it cannot carry sufficient fuel to be a very long distance scout.

It is therefore very important to have ships specially built to enable the planes to be carried out to sea to a point of vantage from which they can start on their duties. The problem of landing on one of these vessels has not yet been satisfactorily solved, but it is most important that it should be, for the hoisting in of the seaplane can only be safely accomplished in fairly smooth water, and, as the supply of pilots and seaplanes must necessarily be limited, it is of great importance that they should be preserved as much as possible.

In waters containing numerous islands flotilla warfare can be maintained at its best; islands not only form refuges for a flotilla, but also give smooth water on their lee side for the landing or starting of the seaplane, while small wireless stations can be erected on them in such positions that the short-distance installations carried by aircraft will always find a receiving station within their radius. Another benefit which comes from Nature's prodigality in the way of islands in an archipelago is the certainty with which the seaplane can locate, not only its own position, but that of an enemy whom it wishes to report.

In most seas, however, the aeroplane has to work without this assistance, and for Great Britain it is essential that aeroplane ships should be built; although the cost undoubtedly will be great, it must be remembered that, for over half the days of the year, at the lowest estimate, aeroplanes will do the work of ten cruisers.

The ideal seaplane should therefore be of considerable size and lifting power, with high speed; it should have seaworthy floats, well sprung, with small head resistance. The observer should be in front of the pilot with the propeller behind both of them; the observer should have room and sufficient field of vision to enable him to work a light automatic gun (0·303″ calibre); the passenger, pilot, and engine should be well up out of the spray, and, if a biplane, the lower planes not too near the water; fuel, ammunition, etc., must all be considered; and all these considerations point to the seaplane becoming larger in the near future.

Although flying over the sea is considerably smoother work than flying over the land, yet the difference in navigation is very real. The wind bloweth where it listeth, and no man knoweth whence it cometh or whither it goeth; and with it goes the aircraft, with no other guide but the compass; and whereas the ship may, by a strong current, be taken twenty miles out of its position in twenty-four hours, the aircraft can double that error in sixty minutes!

This is another problem for the scientist.

But still a conscientious observer can give a great deal of assistance to his pilot by carefully noting down any facts that come to his notice, such as the flight or hovering of sea-birds, the smoke of steamers, the positions of sails or the course of sailing ships, and sometimes, if not flying too high, the direction of the break of a wave. Most careful notice should always be taken before leaving the land, or the depôt ship, of the direction of the wind; it is also of great value to notice the bearing of the sun before leaving, if haply the sun is shining, and also to notice what drift there has been since leaving the point of departure before that object disappears from sight.

There are possibilities for another kind of seaplane—a small fast one, to be carried on board a cruiser or battleship. These must be planes easily handled and quickly assembled and taken apart, and the launching gear must be built so as to be put up and taken down in less than ten minutes. The different methods of launching and receiving a plane on board ship, that have so far come to the writer's notice, do not appear to be satisfactory to the ordinary pilot in weather which is too bad for the plane to alight on the sea.[1]

It is well to add a word on the subject of bomb-throwing from aeroplanes. It is not considered that anything very important will result yet from attempts of this kind in war; it is extremely difficult to drop a bomb accurately from any height, and height must be maintained in order to keep out of the range of ships' guns. The bomb carried must necessarily be small, and by reason of its lack of size, it will be very ineffective upon the deck of a battleship; it is therefore considered that for the present the weight and space occupied by bomb-dropping machines can be better utilised in other ways.

If it should become necessary for a seaplane to attack a dirigible, it is at first important to know whether she carries guns on the top of her balloon as well as under it. In any case, the attack from above is at present the best method, as the officer is command of the steering and propelling machinery controls is underneath the balloon, so that an aeroplane can manœuvre with advantage in the large area overhead, where she cannot be seen by the officer directly controlling the movements of the dirigible. The aeroplane will be the first to see her large enemy, and having done so, should at once rise, keeping in sight of her objective adversary. About 8,000 feet should be a sufficient altitude, and having attained that, she can proceed immediately over the airship and commence her operations, her movements and range being guided by the knowledge she will shortly attain as to whether the enemy has a gun on the top of the balloon.

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[1] The reader is referred to the remarks on 'Deck-planes' in Chapter XV.

There are various ideas as to the projectile or weapon with which the small craft should attempt to destroy the large one. The dropping of fireballs which will stick to the envelope of the gas-bag and, eating their way through, will set fire to the hydrogen gas, is, in the writer's opinion, probably the most effective method. Besides this, the French have been experimenting with an arrow carrying a fiery tail; and thirdly, the late Mr. S. F. Cody proposed carrying a grapnel hook at the end of a line, which he suggested towing through the skin of the dirigible. This latter method savours rather of a forlorn hope, and one would not be surprised if the intrepid aviator found himself either looping the loop inadvertently, or anchored to one of the frames of a rigid airship.

CHAPTER XVII

WIRELESS ON AEROPLANES, FROM NOTES CONTRIBUTED BY THE HON. GUGLIELMO MARCONI

In general it may be said that, for military purposes, the transmission of messages from aeroplanes is more important than the reception of messages on aeroplanes.

Owing to the speed at which an aeroplane travels, the range of transmission of the apparatus should be at least fifty miles to serve any practical purpose.

The range obtained with a wireless transmitter of a given power is greater from an aeroplane to a land station than between two land stations, owing probably to the absence of obstacles in the path of the waves, which would tend to absorb or interrupt them.

The receipt of messages is effected by means of telephone receivers, and it is affected not only by the power of the transmitting station, but also by the relative position of the engine and propeller of the aeroplane, and of the operator.

The amount of training required to become an operator depends largely upon the man himself. Some two or three months is sufficient in most cases to turn out an efficient operator, although for working a 'station' on an aeroplane it would be advisable to employ a man of several years' experience in the handling of wireless apparatus, and the receipt of messages by sound. If,

'Daily Sketch']

BALKAN WAR, WAR TRAINS AT MUSTAPHA PASHA

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however, the 'station' is only used for transmitting purposes a man with less training could do the work.

It is necessary that a wire or wires be trailed from the machine, but these are fitted with safety release devices and winding-in reels. The length of these wires need not be greater than 70 or 100 metres. It is a simple matter to carry spare wire and, after losing a wire in landing, to replace it. It is not practicable to employ the network of bracing wires used in the construction of an aeroplane, because they become 'alive' and would be a source of embarrassment, and even danger, to pilot or passenger.

The operator must wear a helmet of suitable design for eliminating as much as possible the noise of the motor and the noise produced by the wind.

The apparatus is driven by the aeroplane engine, either through a belt from the fly-wheel, or in cases, such as the Gnome motor, from one of the timing pinions. It absorbs less than one-third of one horse-power. The moment the apparatus is geared up to the motor communication becomes possible.

The question of interference with messages is solved, in the case of wireless on aeroplanes, in the same way as with wireless on board ship, by use of different wave-lengths and different spark frequencies.

The Marconi wireless telegraph apparatus for aeroplanes has a power of ½ kw., with a minimum guaranteed range of seventy miles. The weights of the component parts are as follows:

Transmitting apparatus	80 lb.
Receiver	15 to 20 „
High-frequency generator and disc discharger .	70 „

These weights include the travelling cases in which the instruments are mounted, and could be considerably reduced if the apparatus could be fitted permanently to the machine, making use of the frame of the machine to support the apparatus.

The range of transmission which is guaranteed does not represent the maximum range obtainable, and although this maximum range has never been tried experimentally, it would probably be in the neighbourhood of 120 to 160 miles.

The transmission of messages is effected by means of a Morse key operating the primary low-frequency circuit. The transmitter emits a musical note by means of the disc discharger.

This set has been constructed with a view to reducing, as much as possible, the work of erection on any type of aeroplane and without having materially to alter or to damage the machine, and every unit is self-contained and can be arranged to fit on to the machine without any permanent fixtures.

The generator is a 5 kw. self-exciting alterator with a rotary disc discharger fixed on the main shaft, running at a speed of about 2,000 r.p.m. This machine is very compact and can be easily driven by either gears or chain from the main engine shaft, and is so totally enclosed that it can be fitted in any part of the machine without fear of injury from oil or dirt.

The transmitter, which comprises a step-up transformer, a bank of tube condensers, and the primary and secondary of the high frequency oscillation transformer, is contained in a wooden box which can be fitted either inside or outside the aeroplane, according to the type of machine and the room available.

The receiver is of the latest pattern flexible crystal type and is specially designed to allow of various detectors being used in conjunction with it, and it is mounted in a wooden box which can be fitted either in front or at the side of the passenger seat, and in either position can be easily worked, as all the necessary tuning adjustments are accessible in either position.

The aerial is of flexible bronze hemp cored cable, and is contained on a light drum which can be mounted on any part of the machine, without piercing the framework, by means of special clips.

The wire can, if required, be wound or unwound, by means of a special attachment, in a particularly short time, so that, in the event of a sudden landing on bad ground or any other similar emergency, the trailing wire can easily and quickly be wound in. Many types of aerial have been tried, and the one which has always proved most satisfactory is the trailing wire, fixed either at the tail skid or some other suitable position.

A safety catch is arranged for in the aerial wire, so that if, through any accident, the trailing wire should catch in anything during flight the catch would release it and prevent shock or damage to the machine.

CHAPTER XVIII

USES OF FLYING[1]

THE cost of aeroplanes and their upkeep having hitherto been heavy, the use of aircraft for other purposes than pleasure or war has necessarily been extremely restricted and, indeed, more or less experimental. It has often been deplored that so glorious a conquest as that of the air should appeal to man primarily as the opportunity which it offers him of waging more scientific and deadly warfare, but there are two sides to every picture, and while we may deplore this use to which, it seems, aircraft must inevitably be put, it were well not to overlook the fact that without this incentive aeronautical invention would not have received the stimulus that it has had, and the manufacture of aircraft on a large scale would have been impossible. In the nature of things, also, there would have been far fewer flyers, so that the war stimulus to aviation is having the effect of enormously hastening progress in design and in the art of flying. From this the peaceful arts will profit in the near future. Out of evil good will come.

For reasons that have already been explained, only the wealthy, so far, have been able to fly for pleasure, and it has been triumphantly asserted by many people that it will be impossible to carry goods, mails, or passengers by aeroplane at a profit. That this view is erroneous has already been shown. It remains to be explained for what purposes the aeroplane in its present form, or in the form to which it must clearly attain within the next three or four years, can be used. Mails were carried by aeroplane as long ago as 1911, and because of the novelty, and on account of the heavy fees charged to those who dispatched letters by this means, a considerable profit was made. This was the occasion of the aerial mail from London to Windsor. But in a little more than two years from that time an aerial mail was established in all seriousness in France. On October 15, 1913, a regular aerial mail service was inaugurated, mails being carried from Paris to Bordeaux to catch the West Indian boat. A saving of many hours was thereby effected, and this was esteemed of so much value by French business men that the service was well patronised. Such a service can be carried on even now, with the very faulty apparatus at present available, with almost perfect regularity. Only the very worst weather need interrupt it. The aerial mail suggests a general speeding up of postal facilities even in Great Britain, and on important lines of traffic it will always be found that there are thousands of people willing to pay threepence or sixpence extra for the saving of a few hours. It should be possible to carry late mails to a mail boat already started on its voyage and to drop the bags on her deck without stopping. And it is easy to foresee this being done between British cities and Queenstown, or just outside it, to catch the trans-Atlantic service. In countries that are less efficiently served by railways and steamships, the aeroplane must inevitably play a large part in mail-carrying.

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[1] The reader is referred to Chapter XV., 'The Future of Flying,' in which, also, some of the uses of flying are considered.

Mails were carried at Allahabad in India in 1912. In the United States mails were carried in the same year between Nassau Boulevard on Long Island and Mineola, and the inauguration flight was described by an American journalist in the following manner:

'The flying events of the day at the Nassau Boulevard aviation meet came to an end in a hubbub of joyousness among 1,500 spectators on the grounds. Lieutenant Milling had busted the American record and was still flying for the world's record when a tall, youngish man, decked out in a blue serge suit and a gray cap, climbed into the Curtiss machine, driven by Captain Paul Beck of the army.

'"The Hon. Frank H. Hitchcock, Postmaster-Gen'rul of the whole United States," the megaphone man began to holler, "will now fly to Mineola with Captain Beck to deliver the mail. Postmaster-Gen'rul Hitchcock of the United States will carry the mail-bag on his knees and drop the bag at Mineola into a circle in which will be the Postmaster-Gen'rul of —I mean the Postmaster of Mineola. Ladies and gentlemen, Postmaster-Gen'rul Hitchcock." (Much applause.)

'Mr Hitchcock wasn't around to hear all this and so didn't lift his gray cap in acknowledgement. He was far out on the field with Attorney-General Wickersham and Captain Beck. Post-Office-Inspector Doyle handed the Postmaster-General a mail-bag containing 1,440 post-cards and 162 letters, and Captain Beck and the Postmaster-General hiked off in a northerly direction for the high spots. The Curtiss circled three-quarters of the field and then climbed rapidly until it was 300 or 400 feet above the south end of the track. Ovington, who had also got under way with a second bag of mail in his monoplane, shot up into the same area of sky occupied by Captain Beck and Mr. Hitchcock and shot eastward as a track finder for Captain Beck's machine.

'The field could see the two machines almost all

' Daily Sketch ']

BALKAN WAR. A CAMP NEAR MUSTAPHA PASHA

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the time during the cross-country flight. The way the biplane with a passenger pegged along just behind the monoplane with only a pilot aboard was a caution. Over a big white circle painted on the Mineola real estate, Ovington from his monoplane and the Postmaster-General from Captain Beck's machine plumped down to Mineola the two pouches and hit within the circle in each case. The biplane teetered slightly as the mail bag was released and then the two machines made a circle and spun back to where the crowd stood on tiptoe peering over fences at Nassau Boulevard.

'"I was up once before," the Postmaster-General said after he had shaken hands all round upon his return to earth. "That was at Baltimore with Count de Lesseps in his Blériot. The biplane to-day I found was much steadier. Fly again? I hope so, because I like the experience very much. My trip to-day was especially enjoyable because at Baltimore I could see very little of the ground below, owing to the closed-in construction of a monoplane. To-day from the biplane all this end of Long Island was stretched out to be looked at. Yes, air-routes are all right for practical mail-carrying," Mr. Hitchcock continued, in answer to a question. "I mean," he smiled, "the air is all right, but the vehicles must continue toward perfection. But even with the aeroplane as it is now it would be very useful to us, particularly in some parts of the country. Take along the Colorado River in the cañon district of Yuma, for instance, or in parts of Alaska. Along the Colorado there are places where detours of fifty miles out of the way are made in mail routes to get to a bridge. An aeroplane could hop right across the river. The expensiveness of maintaining an aeroplane service is an obstacle, but that will diminish."

'During the next few months he granted permission to a number of aviators, including Ovington, Milling, Arnold, Robinson, Lincoln Beachey, Charles F. Walsh, Beckwith Havens, Charles C. Witmer, and Eugene Godet, to act as special mail carriers, and these men carried mail bags in similar exhibiting tests, from aviation fields to points near the Post Office. Among the cities where such tests were officially made were Rochester, N.Y.; Dubuque, Iowa; Fort Smith, Ark.; Temple and Houston, Texas; Atlanta, Savannah, Columbia, and Rome, Ga.; and Spartanburg and Salisbury, N.C.'

Aircraft may even, in certain cases, render railway-making progress in outlying parts of the Empire, and in countries that are not yet opened up, somewhat problematical undertakings, and, save where the conveyance of heavy goods must be considered, the way of the air may ultimately be chosen in preference to the iron road. Egypt, Australia, Canada, and South Africa will have regular aeroplane services between outlying stations and towns not yet served by railways. The British Colonies, indeed, are somewhat behind the times as regards aviation. The Belgian Government has already established aeroplane communication in the Congo State, the French are doing the same thing in Tunis, Morocco, and Senegal; and the Germans in the Far East. But, among the people who have learned to fly lately in England, there have been a large number of officers of the Indian Army and many Australians. So it is certain that interest is being awakened. It is impossible to exaggerate the importance of aeroplane communications in countries where the white population is widely scattered, and no means of communication exist save by occasional long and weary journeys over bad roads or scarcely perceptible tracks.

In geographical exploration aircraft are capable of playing a very important part. Those vast unexplored regions on the Amazon would soon reveal their secrets to explorers using hydro-aeroplanes and making excursions from the river and from its tributaries. And there are many other parts of the world, such as Arabia or Australia, which could be explored by no other means at present available than aircraft. Projects have already been mooted for taking aeroplanes to the Poles, but the difficulties in this case are tremendous—as they are with any motor-driven vehicle—a fact which Captain Scott found to his cost in the Antarctic. The failure of several ambitious projects of aircraft exploration have been due to man's impatience leading him to attempt the impossible with craft so imperfect as aeroplanes in their early days. But these failures should not blind us to possibilities of the future. Wisely used, the aeroplane will expedite geographical exploration and save the lives of explorers. Photographs can be taken while flying over inaccessible or very difficult regions.

It is pointed out by one authority[1] that 'The supervisor of the Selway forest, consisting of 1,600,000 acres, which was formerly part of the Nez Perces reserve in Idaho, predicts that aeroplanes and wireless telegraphy will be important factors in forest fire prevention before a far distant date. He believes that a man in an aeroplane could do more accurate and extensive survey work in the forests of the Pacific slope country in a few hours, when forest fires are raging, than is usually accomplished by twenty rangers in a week. With wireless stations installed on peaks in the chief danger zones, he believed it would be a comparatively easy task to assemble men and apparatus to check and extinguish the flames and prevent fires from spreading.'

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[1] *The Curtiss Aviation Book*, by Glenn H. Curtiss and Augustus Post.

In the same book it is said that aeroplanes could be of immense assistance in the work of life-saving round the coasts. Coastguard stations could be equipped with an aeroplane to fly to wrecks and carry a line from shore to ship when the high seas make it impossible to launch a life-boat. It might be impracticable to go out during the period of severe storm, but there is always a calm in the air after a storm, as well as the proverbial calm before one, while the high seas, in which a lifeboat cannot live, continue for a little while. The aeroplane or the hydro-aeroplane, dashing through the air, even through high wind, would bring the line that means life to helpless men clinging to a wreck.

In 1910 Dr. Emile Reymond, a French Senator, became a qualified aviator, and subsequently obtained the superior military brevet. He travelled through his constituency by aeroplane, and in a country where aviation enthusiasm abounds as it does in France, it can safely be assumed that he increased his popularity. Politics in England will have undergone an intellectual and moral revolution if, in the course of the next few years, many candidates for Parliament do not see that in the aeroplane they have an unequalled means of advertising themselves and exciting the admiration of voters, more particularly of young lady voters should they by that time be enfranchised. Compared with flying round the constituency, administering the kick-off at the local football match is tame.

A gentleman at York, while suffering with neuralgia, went up as a passenger in an aeroplane. On returning to earth he discovered that the pain had gone, charmed away, at any rate for a time, by the exhilaration and novelty of flying. Flammarion, the aeronaut, recorded the fact that, despite the protests of his friends, he made a balloon ascent while suffering from a severe influenza cold. He came to land after a few hours in the upper air without a vestige of the cold. Hubert Latham was threatened with consumption, but he enjoyed good health after taking up aviation. Almost incredible as these statements may seem to many people, they will occasion no surprise to airmen. The beneficial effect of a journey in the air is acknowledged, and it is readily explained by the greater purity of the air above, and, in the case of aeroplane journeys, possibly by the increase of oxygen due to the rush of air. It is certain that these have a tonic exhilarating effect. Perhaps this is more marked where the ascent is made out of the impure air of a large city. It is well to know that in twenty minutes you can exchange the asphyxiating fog of London for an atmosphere more clear and pure and bracing than that of Davos Platz. Harley Street, to preserve its reputation as the home of all that is best and latest in medical science, will have to put aeroplane flights into its list of up-to-date remedies. Surely the day of the hospital airship or 'public lunger' pictured by Kipling in 'With the Night Mail' is near at hand.

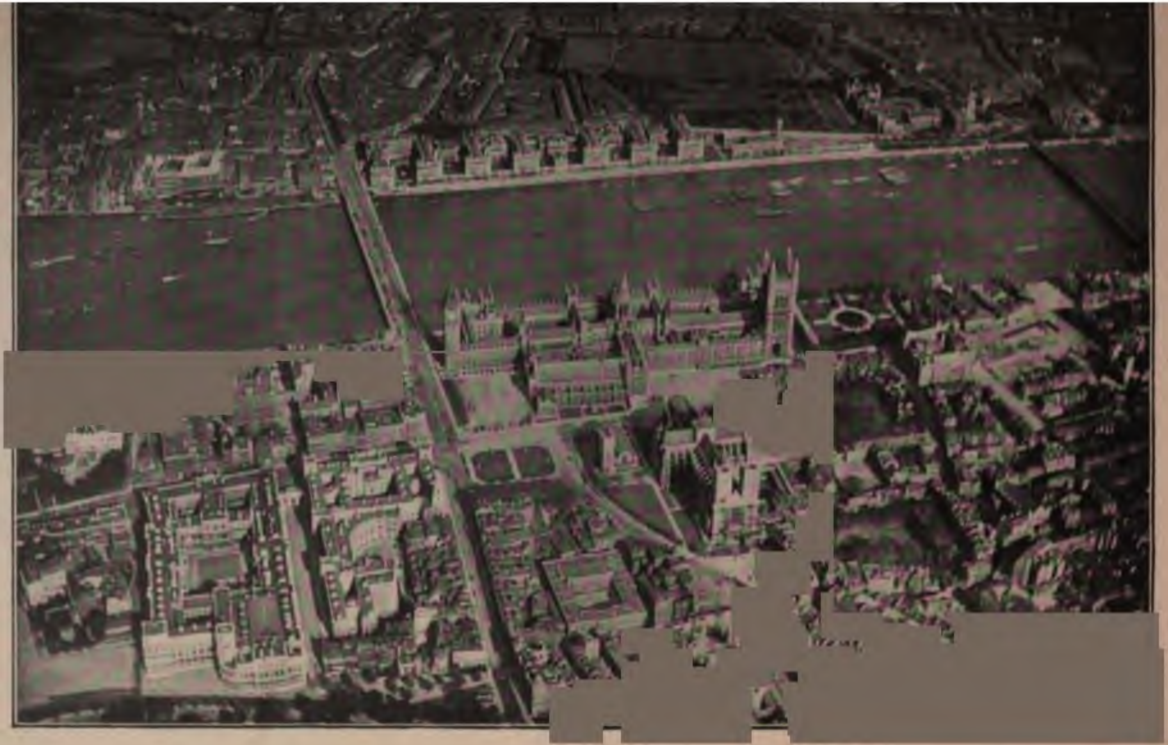
'Savages used to haul their sick and wounded up to the tops of hills because microbes were fewer there. We hoist them into sterilised air for a while,' says Tim.

CHAPTER XIX

PHOTOGRAPHY

Of all kinds of photography taking pictures from an aeroplane is perhaps the easiest. Those difficult questions of choice and treatment of subject, which take the landscape photographer years to solve satisfactorily, do not arise. All that is necessary to master is the one detail of exposure, and this is simplicity itself. A very simple camera, provided with a shutter that will work at a two-hundredth of a second, will suffice for ordinary work. Pictures can be secured giving sharp definition if the light be good, and these are capable of enlargement. But something is to be said for the employment of special apparatus, by means of which the best results can be obtained.

It may seem to the photographer who has never taken pictures in the air a strange assertion that an exposure at a two-hundredth of a second is sufficiently brief when travelling in a machine at sixty or seventy miles per hour. But it must be remembered that even at the small altitude of 500 feet the apparent motion of the earth, as the aeroplane pursues its way, is very slight: the landscape rolls along beneath the machine in a leisurely way, and so far as this factor goes, an exposure of one-hundredth of a second would probably be sufficient. But a disturbing element is the vibration of the engine, which would almost



WESTMINSTER

(Taken by Mr. W. J. S. Lockyer, on May 22, 1909, at 4.30 P.M. from the balloon 'Corona')

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inevitably spoil any picture to which a longer exposure than a hundredth of a second was given. In this respect, it is probable that machines driven by rotary motors vibrate less than those with fixed-cylinder motors; indeed, excellent photographs have been taken with a nominal exposure of one-hundredth of a second, which in reality was fully one-seventieth of a second. One reason why a very brief exposure is desirable is the amount of light and, more particularly, the absence of deep shadow in the subject. The established rule of exposing for shadow obtains in this as in all other kinds of photography. But looking down on the earth from a high altitude the landscape does not present light and shade in marked groupings. Everything looks flat, and even with the sun low down on the horizon the shadows of houses and trees are extremely small features in the great expanse. That being the case, it is not possible to secure depth in the picture, Over-exposure is a thing to guard against, and it is far better to err on the side of under-exposure, in which respect aerial photography is very different from terrestrial. When the landscape is lit by a strong sun from a clear sky, an exposure of one-thousandth of a second will be found sufficient, and even then a small stop may be used.

It would be desirable to use plates, for reasons which need not be explained here, being sufficiently well known to every camera user. But, unfortunately, plates are too heavy to be carried aloft in a large quantity, and they are apt to be broken in the case of a bumpy landing. They have the further disadvantage of being carried singly or in pairs in the plate holder, so that after every exposure the exposed plate must be withdrawn (with holder) and a fresh one slipped into the camera. On the other hand, films, either in the roll or in the flat form, are very light, they are unbreakable, they are made up in dozens, or in half dozens, and an exposed film is changed for a fresh one by a fairly simple movement. The airman photographer will, however, be well advised to have an apparatus ready with which he can use plates on occasion when some very special result is required.

Pictures taken from a height of 3,000 or 4,000 feet often have the disadvantage of including too much in the view. Objects seen fairly clearly with the naked eye are invisible when reduced to the film, so that for military purposes, or for any purpose in which it is required to see detail, such pictures are worthless. Massed troops and baggage trains could be seen in a photograph, say, of half-plate or 5 × 4 size from a height of 3,000 or 4,000 feet, but it is not often that occasions would arise for pictures of this kind to be taken. A telephoto apparatus, although rather cumbersome to use, is an obvious solution of the difficulty. Such a camera can be contrived giving a considerably smaller field than the ordinary apparatus. For example, for special work in aeroplanes a camera of 11 inches extension was made up with a 28 inches telephoto lens and the result was that without any appreciable reduction of light, pictures could be taken from a good height showing much more detail; in other words, taking in far less of the landscape.

Since aeroplane photography is carried on with a certain amount of discomfort and there is some risk of having the apparatus knocked about, the popular bellows form cannot be regarded as suitable, for it takes very little to upset the perfect alignment of this type of camera, with the result that the quality of the pictures is impaired. For all serious work, then, it is advisable to have a box camera made up to requirements, and where this camera is to be used by the hand, that is to say, when it is not so big that it must be strapped to the machine, it should be provided with straps and secured to the photographer's person.

Very convenient are certain special cameras designed for use on aeroplanes. In these the operation of turning the film for each new exposure is automatic, so that the photographer has only to select his subject and press a button or a bulb.

In many aeroplanes the accommodation for the passenger is somewhat cramped, and while he may be protected against the rush of air all the while he crouches back in his seat, the moment he proceeds to take a photograph by holding a camera over the side and looking through the view-finder he becomes exposed to that tremendous gale of wind created by the machine's speed. This at first will be found very disconcerting. And when the exposure is made the familiar click for which the photographer has perhaps unconsciously listened, cannot be heard on account of the motor. On preparing for a second exposure he will find it by no means so comfortable as when on terra firma. The vibration and noise of the engine are disturbing elements, but after some practice these peculiar conditions have little effect.

IMPORTANCE OF MEDICAL EXAMINATION FOR WOULD-BE AVIATORS IS URGED

Efficiency of Medical Selection:

Full Name ....
Address ....
Place of birth....................
Date of birth ....
Residence.........................
Occupation, past and present......

In the examination of the would-be aviator special importance should be given to the following:

Circulatory system:

1. *Heart* for valvular lesions.
2. *Pulse*, pressure, rate.
3. *Blood* for anæmia.

Previous health and habits with special reference to:

Fatigue or exertion.
Nervous exhaustion.
Dizziness.
Asthma.
Faintings.
Fits.
Headaches.
Hæmoptysis.
Injuries.
Insanity.
Irritability.
Alcoholic tendencies.
Nasal Polypi.
Nasal Obstruction.
Neurasthenia.
Paralysis.
Tobacco.

almost. If spectacles have to be worn they should be strapped on and they should be easily cleaned. Any degree of astigmatism should be absolutely corrected or it becomes a good reason for advising against flying.

Achohol should be avoided for various reasons. It acts as a poison to the liver and kidneys, it dilates the peripheral circulation and so tends to lower the body heat, and it inhibits rather than accelerates the rapidity of mental action. A long continued use of alcohol goes to thicken and destroy the resilience of the arteries.

Smoking should also be avoided, especially cigarette smoking, because this affects the heart, causing an irritable heart, which is apt to give rise to palpitation. Tobacco also affects the eyes and causes amblyopia.

Flying should not be taken on a full stomach, although small feeding before a flight is good in order to keep the digestive system engaged.

The use of abdominal belts is certainly a thing to be advised, because it keeps up the tone of the splanchnic areas and so guards against any sudden attack of fainting.

An aviator should take instant notice of certain first symptoms of physical failure. Some of the chief physical warnings would be (1) dizziness, headache, feeling of faintness, pulsation of the temple arteries, and a feeling of nausea. In the higher regions buzzing of the ears not relieved by the swallowing movements, especially if followed or accompanied with hæmorrhage from the nose or ears, is an indication that the aviator has reached a dangerously high altitude. Difficulty in breathing, dyspnœa, especially if sheltered behind a wind screen, is an indication that he should either inhale oxygen or descend to a lower level. Painful and slow muscular movements are also an indication that the aviator has reached his safe-limit altitude.

Gaule in 1901 and by the students of M. Guglielminetti, Sensaude, Jolly, Calugareau, Victor Henri, Abderhalden, von Schrotter, and Zuntz.

Increase in the red cells is a constant phenomenon of high altitude. This increase, which is rapid, is found soon to disappear when inhabitants of high altitudes migrate to lower regions.

It is, however, only fair to point out that there is still a great deal of discussion as to whether this increase is not rather more apparent than real, and is due to concentration of the blood at the surface and the extremities. As will be seen from the findings of many observers, fully recorded later, there seems to be good evidence to show that there is an undoubted increase in the number of red cells in people living at a high altitude. As has been already pointed out, this increase is only present just so long as the person is in a rarefied atmosphere. No such improvement so produced while flying could be made permanent.

Changes also occur in the blood volume of animals placed under novel conditions as regards altitude. Those changes are of a regular character and follow definite laws.

Prof. Dreyer and Dr. Ainley Walker have recently recorded fully in the *Lancet* the results, together with those of other researchers, and their inquiries into the effect of altitude on the blood volume. The results of their observations go definitely to show that 'There is an active new formation of blood in the course of a temporary residence of some weeks' duration in a high altitude, and that about half this increase in hæmoglobin is due to concentration of the blood and about half to new formation of red cells and hæmoglobin. Whilst in animals only resident in high altitudes a day or two, the whole change is due to diminution of the blood volume.' These conclusions were drawn from Abderhalden's work at St. Moritz.

Dreyer and Walker maintain that at first the increase is entirely due to concentration of the blood, whilst the increase due to the active formation of hæmoglobin comes on later. They—unlike other observers—have never found an increase in the volume of the blood, but always a decrease.

Abderhalden in 1902 produced an analysis of an admirable series of observations on the influence of high altitude on the blood. These contain an almost inexhaustible wealth of information and have led to the conclusion that the change in the volume which occurs with a particular change of barometric pressure is proportional to the area of the body surface in different individuals of a given species. For example, the blood volume of rabbits taken up from Basel (226 metres above sea level) and kept by Abderhalden at St. Moritz (1,856 metres above sea level) still conforms to our formula $B = \frac{W\,0{\cdot}72}{K}$. But K is now increased. That is to say, the blood volume is diminished by an amount exactly proportional to their body surface. For brevity, the long tables of calculation by means of which the values of N and K are determined by Abderhalden's figures are omitted. His twenty Basel rabbits, calculated by the formula $B = \frac{W\,0{\cdot}72}{K}$ give a K of 2·43, while his nineteen rabbits at St. Moritz had blood volumes which give a value for K of 2·72. This means a diminution of blood volume of 10·7 per cent. (or nearly 11 per cent.).

At the altitude of St. Moritz the hæmoglobin percentage shows an increase, and the number of red corpuscles per cubic millimetre undergoes a parallel increase. The change is at first due entirely to a rapidly occurring concentration of the blood, as is shown by the immediate rise in the number of red corpuscles and the hæmoglobin percentage (10 per cent. or more within some twenty-four hours). A similar immediate concentration can be seen in the figures obtained by Douglas, Haldane, Henderson, and Schneider, in man, on Pike's Peak, and in a number of other published observations. But in Abderhalden's figures for rabbits, which had been at St. Moritz for from four and a half to eight weeks, the hæmoglobin percentage shows an increase from 11·74, the figure found at Basel, to 14·60. This is an increase in hæmoglobin percentage of 25·1 per cent.

If the increase in hæmoglobin percentage were entirely due at this period to concentration of the blood, the blood volume should have been reduced by 20 per cent.; it was actually only reduced by 10·7 per cent.—that is to say, that of the increase in hæmoglobin percentage 12 per cent. is due to the fall in blood volume (K rising from 2·43 to 2·72) and 13·1 per cent. is due to new formation of hæmoglobin. These together give the total increase in hæmoglobin percentage of 25·1 per cent., a decrease in blood volume of 10·7 per cent. and an increase of 11·7 per cent. in the total hæmoglobin in St. Moritz rabbits as compared with the rabbits kept at Basel as controls.

These two observers go on to discuss—

Influence of Age and Species

As regards age—by which is here implied the progressive increase of the animal in size and weight up to full growth—it may be stated that in any given species younger and lighter animals possess a lower percentage of hæmoglobin both in their circulating blood and in their muscles than the older, heavier individuals. And since, as Ranke showed, the muscles increase more than in proportion to the increase in body weight, it follows that the muscle hæmoglobin increases relatively much more rapidly than the weight of the animal. This fact, as pointed out above, is an important source of error in the application of the CO_2 method for the determination of blood volume.

In different species it is strikingly evident that the mode of life and muscular activity of the species is a factor of importance in determinating the amount and the distribution of the hæmoglobin in the body. Animals which have a high hæmoglobin percentage in their blood have in general a high hæmoglobin percentage in their muscles, and in consequence dark flesh, while those which have a lower hæmoglobin percentage in the blood have also a lower percentage in the muscles and have pale or white flesh. This is seen on comparing wild rabbits with tame rabbits, hares with wild rabbits, ducks with fowls, and adult animals with younger animals of the same species. Moreover, on comparing the hare with the wild rabbit it is seen that the former animal, which exhibits both great endurance and remarkable speed, has a higher hæmoglobin percentage, darker muscles, a heavier heart, and a larger aorta than the latter, whose natural mode of life calls for less exhibition of long-maintained muscular effort and staying power. The hare has more than double the blood volume, 30 per cent. more hæmoglobin in its blood, and about three times as much heart muscle as a wild rabbit of the same size. Similar facts apply to particular muscles and groups of muscles in different animals. The wing muscles of birds which fly are always dark in different degrees, while those of fowls are pale. But in all animals the heart, diaphragm, and intercostal muscles are always dark.

There seems good evidence to show that the quantity of hæmoglobin in the muscles is the index of the amount of physical endurance that a man is capable of. This fact forms one of the reasons for stating that fliers should not be too young—or too light—both conditions being associated with small hæmoglobin content. This also is one of the main reasons for contra-indicating flying during a convalescence following any febrile attack.

Dreyer and Walker on the Regulation of the Volume of the Blood

Under normal conditions the volume of the blood of mammals is very delicately adjusted. The restoration of volume, which as is well known, quickly occurs after hæmorrhage or transfusion (whether of defibrinated blood or of isotonic saline solutions) begins immediately. It is already recognisable by a definite and measurable change in the hæmoglobin percentage when only a very small percentage of fluid has been removed or introduced. This fact adversely affects the value of many of the experiments which have been carried out on bleeding and transfusion, since it has evidently escaped recognition. The application of an elastic bandage to a limb has practically the effect of a transfusion of blood by considerably increasing the volume of the blood circulating in the now diminished vascular area. Accordingly it is found that a rapid concentration of the blood, indicated by an increase in the hæmoglobin percentage, occurs and is already recognisable within a few minutes of the application of the bandage. On removing the bandage the blood quickly restores itself to its former volume by a process of dilution. The effect of cold or warmth applied to the surface is largely comparable to the effect of applying an elastic bandage or removing one from a limb. By its effect upon the superficial vessels it leads to a concentration or dilution of the blood as the case may be.

In further experiments the effect of certain chemical substances on the volume and concentration of the blood has been investigated. In many experiments on respiration and the blood it has hitherto been tacitly assumed that the blood volume undergoes no significant alteration during the period of observation. This assumption is almost certainly erroneous. The presence of an increased amount of carbon dioxide in the respired air produced by breathing into a confined space quickly leads to a dilution of the plasma and an increase of blood volume which may amount to 10 per cent. or even more. This is a new factor which will come into account in interpreting many of the experiments carried out by respiratory methods. The inhalation of oxygen, on the other hand, leaves the blood volume unaltered. The administration of amyl nitrite, which causes vascular dilatation, also leads to an immediate dilution of the plasma. This observation renders it unlikely that an abiding fall in the blood pressure can be brought about under normal conditions by the production of vaso-dilatation. The introduction into animals of chloral hydrate in quantities sufficient to cause anæsthesia produces rapid concentration of the blood with a corresponding diminution of blood volume. This has been demonstrated not only by estimating the increase which occurs in the hæmoglobin percentage, but also by direct determination of the blood volume by means of washing out experiments. The degrees of concentration varies with the dosage, a fact of importance in relation to the pharmacological action of this drug, and one which renders it an unsuitable anæsthetic to employ in work upon the blood and circulation. On the other hand, ether anæsthesia leaves the volume of the blood unaltered.

Other experiments have been performed in order to solve the problem of the increase of red cells. Gaule, alone, has admitted the formation of new red corpuscles. The other most plausible explanation is the unequal distribution of the red cells by vaso-motor phenomena, depending upon, several factors, such as cold, intense light, fatigue, activity of the respiration. Cold, in particular, would be able to bring about by sympathetic excitement the contraction of the peripheral vessels, and would increase thus the ratio of the red globules in each drop of blood. It is necessary first to ascertain if the deep blood, the central blood taken to the heart, underwent the same increase in the number of red corpuscles. The experiments of Armand Delille and André Mayer showed that the blood from the heart did not undergo the increase in altitudes, and that the peripheral blood distinctly presented polycythæmia.

Jolly made analogous authentications in his ascent of June 7, 1905.

Later Armand Delille and André Mayer, Lapicpue and André Mayer, Victor Henri and Jolly, recognised the vaso-motor phenomenon and the influence of cold on polycythæmia.

Verifications were made by Crouzon and Soubies, who have not proved the polycythæmia in a guinea-pig submitted to warmth in a dry atmosphere, and that oligocythæmia was manifested in guinea-pigs left in outside air or in air saturated with moisture. It appears, then, well demonstrated to-day that polycythæmia is only apparent, that it is a vaso-motor peripheral phenomenon—one of the producing causes of which is cold.

These researches led to the conclusion that the real rate does not vary with altitude, but that the apparent modifications found are connected with the relative polycythæmia due to vaso-motor phenomena.

The number of white corpuscles does not follow in altitude the increase in the number of red.

The proportioning of the gases of the blood has been determined by Victor Henri and others. Up to 3,500 metres O and CO_2 contained in the blood did not follow the laws of the dissolution of the gases. They varied inversely to these laws. Azote followed the laws of the dissolution of gases. The quantity of O and CO_2 and the total quantity of the gases contained in the blood increased according to altitude.

Arterial pressure studied by Hallion and Tissot and others seemed to them invariable, whatever might be the altitude. Other authors have found different results. It seems, nevertheless, that these modifications of arterial pressure could depend on other causes, and that altitude has no real influence on arterial pressure. The pressure has been found unaltered at 6,000 metres.

The respiratory changes in altitude have been the object of research by Hallion and Tissot. If the tension of the oxygen diminishes, there is a better use of this oxygen and the respiratory coefficient remains the same; the quantity of carbon dioxide exhaled remains invariable. At a greater altitude the pulmonary ventilation can make up for the diminution of the quantity of oxygen, until compensation is no longer made and asphyxia commences.

Muscular force diminishes according to altitude, and work produces rapid fatigue; in the highest altitudes torpor renders work impossible, and even the least effort is painful. This is one of the surest warnings to aviators.

CHANGES IN RESPIRATION AND RESPIRATORY MECHANISM (*b*)

Respiration as a rule is quickened and becomes deeper as height increases. Loewy noticed this first, and that it especially affects people who are known as superficial breathers. This respiration is due to chemical and physical conditions rather than to mechanical causes and often follows the increase in the rate of the pulse. As pointed out by Hill and others, Cheyne-Stoke-like respiration commonly occurs in people sleeping or resting in Mont Rosa. This respiration and irregular depth of respiration are probably to be ascribed 'to the diminished tension of CO_2 in the alveolar air.' Haldane has shown that the rhythm of respiration is normally controlled by the CO_2 tension in the alveoli, and that this tension is kept remarkably constant. Pembrey and Allen, moreover, have abolished Cheyne-Stoke respiration by increasing the amount of CO_2 in the air breathed. In high altitudes the CO_2 in the air is less, and this, together with the increased pulmonary ventilation produced by oxygen-hunger, lowers the alveolar CO_2 tension. The respiratory centre thus lacks its normal excitant. The CO_2 in the venous blood, moreover, under ordinary conditions raises the oxygen tension by increasing the dissociation of oxyhæmoglobin. This enables the tissues to obtain most of the O in the blood in dyspnoic conditions, produced by stenosis of air-passages, etc. (Bohr). Such action of the CO_2 is prevented by the increased ventilation. Mosso has wrongly regarded the lessened CO_2 tension as the primary cause of mountain sickness.

This altered respiration, which is known as periodic breathing, has been summed up by an observer as follows :

1. The duration of the periodic breathing, which in some people occurs at the end of the apnœa after forced breathing, is lengthened with increase of altitude. When a sufficient altitude is maintained the periodic breathing becomes to all intents and purposes permanent, and affords an opportunity of studying the changes in the alveolar air under conditions which resemble very closely those of typical pathological or spontaneous high-altitude Cheyne-Stoke breathing.

2. The causitive factor responsible for this periodicity of breathing is, ultimately, deficiency of oxygen.

3. The periodicity can be explained in terms of the changes in the gases of the alveolar air, blood and respiratory centre, and it is unnecessary to postulate any alteration, whether permanent or periodic, in the excitability of the respiratory centre.

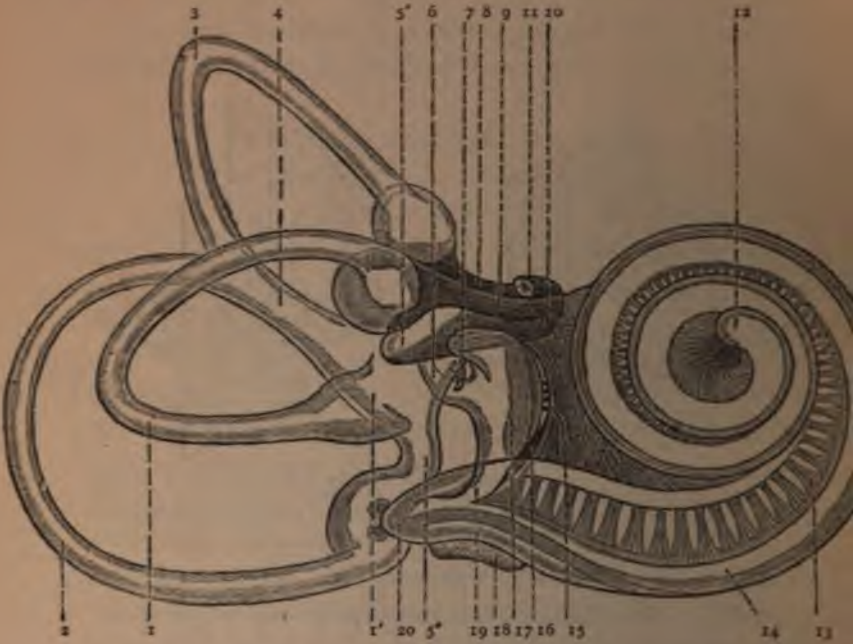
4. Psychic influences are practically negligible in these cases of artificially induced periodic breathing, even though the subject of experiment is conscious.

VISION (*c*)

Vision becomes accentuated while in flight. Various observers of this point have given examples of definite increase in vision up to a certain altitude. After that, owing to other changes, vision rapidly decreases with the onset of dizziness.

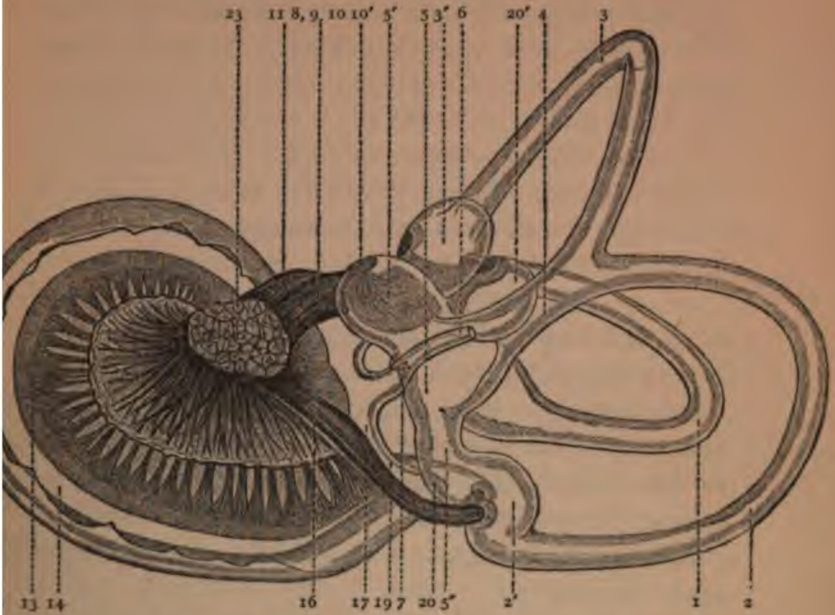
This increase in visual activity is probably due, partly to increased concentration which is of vital importance during a time of strain, and is also in a great measure

The semicircular canals, as their name implies, consist of three canals occupying the posterior part of the labyrinth. The direction of each canal corresponds roughly with one of the fundamental planes of the body, viz., superior = forward and backward; posterior = side to side; horizontal = transverse, in the horizontal plane. The horizontal canal is the only one however quite true. Each canal is at right angles to its fellow (diagram, p. 325). At one end of each canal is the dilatation or ampulla, which contains the stiff hairs in which the nerves end. These canals contain lymph (fluid) which when set in motion by the head, affect the fine hair brushes and so impulses are conducted to the brain.



RIGHT HUMAN MEMBRANOUS LABYRINTH, REMOVED FROM ITS BONY ENCLOSURE, AND VIEWED FROM THE ANTERO-LATERAL ASPECT. (G. Retzius.) *From Quain's 'Elements of Anatomy.'*

These as have been described are set up by the varying pressure of the fluid in the ampullæ. For example, a



THE SAME FROM THE POSTERO-MESIAL ASPECT. (G. Retzius.)

(The numbers include those of the preceding figure.)

1. Lateral semicircular canal; 1'. its ampulla. 2. Posterior canal; 2'. its ampulla. 3. Superior canal; 3'. its ampulla. 4. Conjoined limb of superior and posterior canals (sinus utriculi superior). 5. Utricle. 5'. Recessus utriculi. 5". Sinus utriculi posterior. 6. Ductus endolymphaticus. 7. Canalis utriculo-saccularis. 8. Nerve to ampulla of superior canal. 9. Nerve to ampulla of lateral canal. 10. Nerve to recessus utriculi (in the above figure the three branches appear conjoined). 10'. Ending of nerve in recessus utriculi. 11. Facial nerve. 12. Lagena cochleæ. 13. Nerve of cochlea within spiral lamina. 14. Basilar membrane. 15. Nerve-fibres to macula of saccule. 16. Nerve to ampulla of posterior canal. 17. Saccule. 18. Secondary membrane of tympanum. 19. Canalis reuniens. 20. Blind ending of cochlear canal in vestibule. 21. Outer wall of cochlea. 22. Spiral ligament. 23. Section of the seventh and eighth nerves within internal auditory meatus (the separation between them is not apparent). *From Quain's 'Elements of Anatomy.'*

sudden turn of the head from the right will cause movement of the fluid towards, and therefore increased pressure on the ampullary nerve endings of the right horizontal canal and diminished pressure on the corresponding nerve-endings of the left side.

These semicircular canals which are found to be best developed in birds, especially in such birds as carrier-pigeons, have been the subject of much investigation. The fact that they are so well developed in flying creatures is in itself strong evidence of their importance to the aviator. In the whirling or dancing mice in Japan the semicircular canals have been found to be diseased as has been pointed out by Prof. Karl Pearson and others. It is also an interesting fact that even the best aviators notice that they can keep their balance more easily in the horizontal plane than in the vertical plane, that is the lateral swaying as compared with pitching. This is no doubt due to the fact that in the horizontal plane only one set of semicircular canals is necessary whilst in the pitching movements, either forwards or backwards, two sets of these are called into play and hence their sensitiveness is diminished.

Many aviators will tell you the following somewhat interesting fact: they all very much object to flying in clouds or fogs, not from any sense of danger but because, when in the darkness of the cloud, their vision being cut off, the movements of the aeroplane alone are then conducted as the sensations to the brain and give to them a very confused sense of balance; this is owing to the movement of the fluid in the semicircular canals produced by oscillation.[1]

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[1] For fuller details as regards the function of the semicircular canals the reader is referred to Dr. Joseph Byrne's book on the Physiology of the Semicircular Canals and their relation to Sea-sickness, which contains many points of interest and importance to the aviator, besides a complete bibliography on that question which is so nearly related to Air-sickness which is discussed at some length later.

EARS (*e*)

Prof. B. Okouneff, of St. Petersburg, considered the question of aviation from an aurist's point of view. He records the case of three military aeronauts who came to him complaining of noises in their ears and deafness. They said that their trouble came on after going up in a balloon, which each one noticed became apparent in rapid ascents but more often in rapid descents. The patients came to him with regard to the question of compensation for ear trouble from military headquarters.

A series of experiments was then undertaken on animals with the idea of finding out exactly the effect of rarefied air on the ears. A large number of investigators have studied the influence of compressed air on the organs of hearing, and one only has to quote the names of Prof. Leonard Hill, John Lister, Vincent Gomez, Sommerfield, Alt, Heller, Mager, von Schroeiter, Gerard, Tomka, Jacobson, and Politzer. Politzer, however, remarks that although 'with aeronauts the absolute differences of air pressure are incomparably less important than with those who work in caissons or with divers.' However, at any great height, when the ascent or the descent of the patient is rapid, serious lesions may occur in the organ of hearing.

Alt, in order to study the influence of the variations of air pressure on the organ of hearing, went up himself in a balloon and during his trip, when the balloon had attained a height of 9,300 feet, he examined his companion's ears. He observed, from the subjective point of view, that the subject complained more often of a slight auricular noise, a sensation of pressure in the ear, and a decrease in the power of hearing, in proportion to the rapidity of the ascent or the descent of the balloon. The ascent (decompression) produces a sensation less disagreeable than the descent (compression). From the objective point of view, Alt was able to demonstrate the existence of a congestion slightly intense or diffuse; during the decompression it was not noticed that the membrane of the tympanum had been pushed back.

Steinbrugge admits the possibility of hæmorrhages from the nose and from the ears when the balloon mounts to a great height.

The celebrated aeronaut Robertson set off in a balloon from Hamburg in 1803 with a companion and rose to a height of 21,510 feet. During this ascent the two aeronauts felt a general weakness, and a disturbance of the auricular sounds ; these latter became particularly intense when the barometer fell thirteen divisions. The chest seemed enlarged, the lips were swollen, the eyes prominent, the veins of the hands were distended with blood. Mme. Blanchard, who went up 22,800 feet in a balloon in 1912, had a violent hæmorrhage from the nose. With Glasher, who went up over 31,000 feet, there were visual troubles.

Junod, in rarefying the air in an apparatus with a man inside, noted, amongst other phenomena, that the subject had a sensation of pressure on the membrane of the tympanum when the rarefaction attained a quarter of the atmosphere. Crocé-Spinnelli and Sivel, shut up in a pneumatic room where the barometric pressure was 304 millimetres (which corresponds to a height of 21,900 feet), suffered from headache, dimness of sight, and auricular noises. M. Girmounsky has also heard from subjects whom he has submitted to a rarefied atmosphere that they had a sensation of pressure in the ears (on the membrane of the tympanum), and he has explained this phenomenon as an inequality of air pressure in the middle and outer ear. He considers that this symptom is one of those which attract the attention of experimentalists in their tests with rarefied air.

CONDITION KNOWN AS AIR-SICKNESS, ITS SYMPTOMS, ETIOLOGY, TREATMENT, AND SIGNIFICANCE

Air-sickness is a term to denote a definite set of symptoms coming on in a healthy subject when exposed to a rarefied atmosphere.

This condition is well known to balloonists and aviators and really comprises a complex set of signs and symptoms which are really the effects of flying on the general system, and therefore include almost all the changes found in the various parts of the body, some of which are described.

In ascending breathing gets quicker, and this usually occurs at about a height of 4,500 feet. The heart beats more rapidly although there is no palpitation. There is usually no nausea or distension of the stomach as is frequently found in mountain ascents. Towards 3,000 feet hearing becomes acute although soon after this the hearing rapidly diminishes. This phenomenon is particularly distinct in dry weather. Buzzings of the ears usually slight only, make themselves felt at about 5,400 feet. M. Legagneux mentioned that the buzzing occurred at a lower altitude of 3,300 feet, but this was the first time he had ever reached such a height. There is no doubt that the more a person becomes used to flying the higher he can get before any of the well recognised symptoms of discomfort make themselves felt. A passenger who ascended for the first time to 900 feet on a biplane felt this sensation.

Before flight (5.30 P.M.) :

Minimum tension	90	millimetres Hg.
Maximum ,,	180	,, ,,
Pulse	70	to the minute.

At 6 P.M., *after a flight of twenty minutes during which, at the twentieth minute, the altitude of* 3,300 *feet was registered by the barometer carried by the aviator :*

Minimum tension	120	millimetres Hg.
Maximum ,,	190	,, ,,
Pulse	80	to the minute.

After a flight of twenty-seven minutes, maximum altitude 4,500 *feet :*

Minimum tension	120	millimetres Hg.
Maximum ,,	190	,, ,,
Pulse	75	to the minute.

Another aviator after a first flight to 3,300 *feet :*

Minimum tension	95	millimetres Hg.
Maximum ,,	160	,, ,,
Pulse	80	to the minute.

After another flight to 4,140 *feet :*

Minimum tension	105	millimetres Hg.
Maximum ,,	160	,, ,,
Pulse	84	to the minute.

This hypertension, which is verified in many instances, is so much the more remarkable in the case of athletes well trained. It is less apparent in very fatigued subjects, who then show cardiac palpitations and a very great acceleration of the pulse (108 in the case of a young aviator who attained a height of 3,000 feet after an upward flight lasting an hour). This 'tachycardia' is evidently symptomatic of a functional cardiac insufficiency.

The increase in the arterial pressure peculiar to aviators who descend from great altitudes :

Lieut. Z. showed on starting :

Minimum tension	90	millimetres Hg.
Maximum ,,	190	,, ,,
Pulse	80	to the minute.

After landing from a flight lasting fifty-five minutes and to a height of less than 300 *feet :*

Minimum tension	90	millimetres Hg.
Maximum ,,	180	,, ,,
Pulse	100	to the minute.

To formulate an hypothesis on the causes of the modification of the value of the blood pressure—and this may not be without interest in relation to the grave troubles of people forced to do very active brain work with sustained attention—it may be advanced that the organism which descends to the ground in four, five, or seven minutes after having reached 3,000, 6,000 or 9,000 feet in twenty, thirty, or forty minutes, has not time to adapt its circulatory system to the variable pressures (521 mm. Hg. at 9,000 feet, 591 mm. Hg. at 6,000 feet, 760 mm. at 0). This hypertension—vaso-motor reaction—is equivalent to the lowering of the pressure and the troubles of encephalic circulation observed by Lapicque in the course of a rapid descent.

'Air sickness'[1] depends upon the individual, but as a general rule one is able to say that it appears at a height generally *lower* than in ascents on foot or even in a balloon.

What is the pathogeny of the symtoms pointed out ? Numerous controversies, which have been the cause of a great deal of research on mountain-sickness and air-sickness, scarcely permit a conclusion on the genesis of the troubles observed. But very noticeable are the constancy and the importance of the variations of the arterial pressure, and which are particularly noticed after ascents and rapid descents from high altitudes more than with flights at moderate heights by experienced aviators—the latter being unaccompanied by any distinct reaction.

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[1] The disturbance due to much rocking and pitching of the machine is, of course, another matter.

Vaso-motor reaction with hypertension giddiness, headache, somnolence following on an ascent, and particularly when on land and some time after the landing—such are the phenomena which distinguish air-sickness from mountain-sickness, and give a particular aspect to certain troubles, the essential cause of which is really the rapidity with which the aviator transports himself into space. It is this factor which makes the variations of atmospheric pressure more troublesome and dangerous, although relatively small compared to the variations of pressure to which divers are subject.

Cause and Remedy for Air-sickness

Bert has rightly attributed all the symptoms to want of oxygen, and his analyses were supported by others such as Frasnkal and Jeppert. This simple and satisfactory explanation was rendered difficult by Huffner's dissociation curve of oxygen. However it seems conclusively proved that want of oxygen is the chief cause of air-sickness.

The remedy is therefore simple, namely, that cylinders of oxygen be always carried on a high altitude flight. The apparatus should be simple and easily worked because muscular activity is diminished. The administration of the oxygen should be preventative rather than curative.

All these modifications of the organism are accentuated in high altitudes and their grouping produces a symptomatic complexus known as balloon-sickness, identical with troubles experienced on mountains and called mountain-sickness. It is this balloon-sickness that was experienced by Biot and Gay-Lussac, Glaisher and Coxwell, and Gaston Tissandier, Sivel and Crocé-Spinelli in the ascent of the 'Zenith,' the two latter of whom succumbed to balloon-sickness. It consists of difficult breathing, loss of appetite, nausea and vomiting, loss of muscular energy, accelerated pulse, venous congestion of the face with nasal and pulmonary hæmorrhage, diminution of urinary secretion, headache, torpor, numbness—in fact, a sensation of well-being and a tendency to sleep which precedes death.

Several theories go to explain balloon-sickness, but we will discuss only two of them :

1. The theory of anoxyhémie of Paul Bert, according to whom the diminution of the oxygen is the only cause of this sickness. Paul Bert was able to verify his theory in the bells which he had constructed and was able thus to advise the use of oxygen to the aeronauts of the 'Zenith,' and if the torpor had permitted them using this provision the catastrophe would have been avoided.

2. The theory of acapnie, according to which the lack of carbonic acid in the blood (Mosso) would be the cause of balloon-sickness. There would be still room, according to Agazzotti to breathe a mixture of 13 per cent. of CO_2 for 87 per cent. of oxygen in altitudes.

We have sought to verify this theory with Jacques Soubles in an ascent piloted by Omer-Decugis and we have arrived at different conclusions from those of Agazzotti. To us pure oxygen has appeared superior to a mixture of carbonic acid and oxygen. Certain precautions should be observed in inhaling oxygen. By means of a hanging apparatus, Draeger-Guglielminetti allowed a regular flow of oxygen in quantity of 1, 2, 3, 5, litres per minute and then applied a mask communicating by a pipe with the vessel, this caused the aeronaut to avoid all effort in carrying to his mouth the vivifying gas.

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